NATIONAL ELECTRICAL SAFETY CODE

THIRD EDITION
OCTOBER 31, 1920

HANDBOOK SERIES
OF THE
BUREAU OF STANDARDS

No. 3

(U.S. Standards)
3-VGX

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
S. W. STRATTON, Director

NATIONAL ELECTRICAL SAFETY CODE

THIRD EDITION
OCTOBER 31, 1920

HANDBOOK SERIES
BUREAU OF STANDARDS

No. 3

PRICE (CLOTH BOUND), 40 CENTS
Sold only by the Superintendent of Documents, Government Printing Office
Washington, D. C.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1921

PREFACE

About four years ago the Bureau of Standards published the completed text of the National Electrical Safety Code for examination and trial use, an early revision being contemplated. War conditions interfered with this trial, so that the publication of a new edition has been greatly delayed. This revision has now been completed, and the revised code is offered in the form of a handbook for more convenient use. The discussion of the rules has been segregated under a separate cover so as to reduce the bulk of the main volume, and will appear as Bureau of Standards Handbook No. 4.

It will be noted that two sizes of type have been used in the text. The larger size has been used for the body of the rules and to give prominence to the more essential parts. Paragraphs which may well be passed over on first reading have been put in the smaller type, even though they sometimes contain important rules. Such paragraphs may contain details of rules, exceptions to rules, alternative methods, suggestions for meeting rules, or mere explanatory notes.

Criticism of the rules contained in this edition and suggestions for their improvement are invited and every effort will be made in preparation for the next edition to perfect the rules both in the development of detail and in the modification of any requirements which it is found can be improved.

S. W. Stratton, *Director*.

October 31, 1920.

CONTENTS

[A more detailed table of contents is given at the beginning of each part]

NATIONAL ELECTRICAL SAFETY CODE

INTRODUCTION

In the preparation and revision of this code the Bureau has had the cordial cooperation and assistance of many State industrial and public-service commissions, municipal electrical inspectors, engineers of operating and manufacturing companies, committees of engineering societies, and representatives of the fire and casualty insurance interests, and of the electrical workers. Without such cooperation the work would have been impossible. With it progress has been rapid, considering the magnitude of the task, and the interests of all concerned have been considered. It is hoped that the revised code will receive the very general support of all those affected by it.

SCOPE OF THE RULES

The rules of this code have been divided into four parts. Part 1 refers to the installation and operation of machinery, switchboards, etc., in central stations and substations. Part 2 contains rules for the installation and maintenance of electrical supply and signal lines, both overhead and underground. Part 3 contains rules for the installation and operation of electrical apparatus and wiring in factories, offices, residences, or other places where electric light and power are utilized. Part 4 contains rules for safeguarding employees working about electric machinery or lines. A supplementary section gives rules for protective grounding of circuits and equipment.

The rules have been made to recognize conditions as to climate and density of population where these involve a difference in the hazard or the number of persons exposed to the hazard. This is particularly true of overhead lines. No previous set of rules has definitely recognized these differences in hazard. This treatment of the subject has added a considerable amount of detail to the rules, but none of the conferees consulted has recommended brevity at the expense of clearness and reasonableness, and the detail thus brought in will tend to prevent misunderstandings between administrators and those to whom the rules apply. Many of the rules are not yet as specific as may be desired by some, but development in this direction must wait upon experience secured by application of more general rules. Advantage of such experience is expected to be taken in future revisions of the rules, which are contemplated at reasonable intervals.

The rules of the code consist of two general classes—those which are mandatory and those which are not. The former are characterized by the word "shall" which indicates that the rule is mandatory, subject only to modification or waiver as indicated in the rules themselves.

The word "should" indicates that a rule is of an advisory or recommendatory nature. Experience and best practice have usually determined that the type of construction or operation which is recommended is desirable in most cases and in some cases is necessary to eliminate the probability of accident. Because of numerous exceptions, and of differences of conditions or of opinions as to protective values, recommendation rather than universal enforcement seems preferable for such items. The installer or operator who fails to apply such rules must weigh the cost of the construction recommended against the cost and other results of an accident, and must be prepared to shoulder the responsibility if his judgment proves to be ill-advised. A number of the rules which are of an advisory nature may appear to involve fire hazard mainly, but it must be remembered that a fire hazard is in most cases also a personal hazard. Consideration must, therefore, be given to such rules in a safety code of this character.

HISTORY OF THE RULES

Part 4 was first published in August, 1914, as Circular No. 49 of this Bureau. It was revised with the cooperation of the Committee on Accident Prevention of the National Electric Light Association and republished in May, 1915, as a second edition of that circular. The other three parts of the code were printed as Circular No. 54 in April, 1915, after which they were developed and greatly modified through study and the criticism of many conferees. A second edition was published in December, 1916, and widely distributed. This edition has received careful study and considerable use. It was recommended to the attention of the electrical utilities in many States having public-service commissions, and parts of it were adopted by the commissions having appropriate jurisdiction in certain States and used as a basis for orders issued in a number of others. It has, however, been more largely used as a work of reference for guidance in particular cases.

A large number of formal and informal conferences were held by the representatives of the Bureau with representatives of State commissions, engineers of operating and manufacturing companies, and others, in which the rules of the several parts of the code were critically examined and when necessary amended. Formal conferences usually attended by from 25 to 50 engineers and other representatives of the interests concerned were held in Boston, Schenectady, New York, Philadelphia, Washington, Atlanta, Columbus, Chicago, St. Louis, Denver, Boise, Los Angeles, San Francisco, Portland, and Seattle. Informal conferences were also held in many other places in all parts of the country.

The New York conference, held in the autumn of 1915, was attended by over a hundred persons, chiefly representatives of the public utilities, including some of their ablest engineers. This conference was held at the request of the American Institute of Electrical Engineers, the National Electric Light Association, and the Association of Edison Illuminating Companies. The meeting continued for two weeks; a very thorough study was made of the entire code, and important modifications were made in some of the rules.

A final conference of all interests concerned was held in Chicago on May 29–30, 1916. Some modifications in the tentative rules were made, and there appeared to be as substantial agreement of the delegates who represented all classes of utilities and administrative agencies concerned as it was possible to secure where conflicting interests were involved.

In making the present revision but few formal conferences have been held, and the work has been done largely by correspondence and informal conferences. Photolithograph copies of the old text, with proposed changes indicated, were distributed to all those known to be interested in criticizing these changes, including committees of various associations which have cooperated with the Bureau in this work. As a result of criticisms received, supplementary lists of changes were distributed in mimeographed form, and in the early summer of this year changes for the new edition were finally decided.

In the course of the discussions which were held it developed that there was a definite difference of opinion regarding the strength of construction which it was appropriate to require in the rules. At the suggestion of the Committee on Safety Rules of the National Electric Light Association, the Bureau consequently agreed to participate with that body in a survey of existing wood-pole lines to determine existing conditions in various parts of the country. Observers were sent into the field and visited many of the larger cities of the country from Maine to Florida, California, and the Pacific Northwest.

The data obtained in this survey afford valuable information as to the compliance of existing construction with the requirements of the revised code. A full report of this matter will be found in B. S. Handbook No. 4, which contains a discussion of the rules.

The transverse-loading specification, one of the points regarding which there has not been general agreement and which have delayed the new edition, has been simplified in form and modified numerically, but the apparent increase in requirements for grades B and C is largely balanced by modifications made for selected poles and for averaging poles. The aim has been to improve the form of the specification rather than to call for stronger or safer construction, and it is thought that the revised rules represent good modern practice better than the 1916 code.

AGREEMENT ON THE RULES

It is obvious that in formulating rules of this nature some differences of opinion will naturally arise, and it is hardly to be expected that every rule will be considered satisfactory by those who must work under them. It is impossible to please or satisfy everyone in every detail. The revised draft of the rules represents the best consensus of opinion which the Bureau has been able to formulate, and in most respects it is now acceptable to the various interests which have been consulted in its revision.

This statement is particularly and specifically true of Part 4. No proposals to change the rules of this part of the code were received, and, except for minor items of editing, it remains identical with the previous edition. With respect to section 9 and Parts 1 and 3, there has been very substantial agreement, and only a few minor points have been the subject for serious objection. The portion of Part 2 dealing with overhead-line construction includes the rules regarding which it has been hardest to secure general agreement and as to a few of which there still remains some disagreement. This is largely due to the conflicting interests of the different public utilities concerned with the construction of overhead lines at crossings and conflicts.

The provisions of this edition regarding such points of disagreement will, of course, be the subject of further study not only by the Bureau engineers but by the representatives of the interests most seriously concerned with these subjects. If experience or experiment provides sufficient evidence for changing these requirements in future editions, it will, of course, be done, and every effort will be made to obtain data and accumulate experience sufficient to formulate modified rules which will meet with more ready and general acceptance. The code rules specifically provide for variation from particular requirements when circumstances warrant different practice.

These rules represent a growth and development which have called for important modification from original drafts and previous editions. Development will necessarily continue in the future as in the past. More specific requirements can be worked out with respect to many items covered by the rules, and more definite conclusions can, no doubt, be arrived at in the case of requirements about which there is not yet entire agreement.

SECTION 1. DEFINITIONS OF SPECIAL TERMS

Alphabetical List of Defined Terms

Terms	Definition No	Page	Terms	Definition No.	Page
Alive or live	12	14	Joint use	43	18
Apparent sag	39	17	Lateral conductor	35	17
Apparent sag of span	38	17	Lateral working space	41	17
Automatic	15	14	Line conductor	32	17
Cable vault	47	18	Low-voltage protection	16	14
Circuit	7	13	Low-voltage release	17	15
Circuit-breaker	20	15	Manhole	47	18
Climbing space	40	17	Manual	14	14
Common use	44	18	Normal sag	37	17
Conductor	31	16	Open lines	33	17
Conflicting or in conflict	42	18	Panelboard	55	19
Conduit	46	18	Permanently grounded	10	14
Current-carrying part	11	14	Qualified	22	15
Dead	13	14	Raceway	56	19
Disconnector	19	15	Reconstruction	50	18
Duct	45	18	Rural districts	52	19
Electrical supply equipment	1	12	Service	34	17
Electrical supply lines	3	12	Signal lines	4	12
Electrical supply station	2	12	Substantial	21	15
Explosion proof	29	16	Splicing chamber	47	18
Exposed	26	16	Switch	18	15
Grounded	8	13	Switchboard	54	19
Grounded system	9	13	Tags	57	19
Guarded	23	15	Transformer vault	49	18
Handhole	48	18	Urban districts	51	19
Inclosed	30	16	Utilization equipment	5	13
Insulated	27	16	Vertical conductor	36	17
Insulating	28	16	Voltage or volts	6	13
Isolated	24	15	Wire gages	53	19
Isolation by elevation	25	16			

The following definitions give the meanings of some of the terms occurring in these rules. Terms not defined will be understood to have their usual meanings.

1. *Electrical supply equipment* means equipment which produces, modifies, regulates, controls, or safeguards a supply of electrical energy. Similar equipment, however, is not included where used in connection with signaling systems under the following conditions:

(*a*) Where the voltage does not exceed 150.

(*b*) Where the voltage is between 150 and 400 and the power transmitted does not exceed 3 kilowatts.

2. *Electrical supply station* means any building, room, or separate space within which electrical supply equipment is located and the interior of which is accessible, as a rule, only to properly qualified persons.

This includes generating stations and substations and generator, storage battery, and transformer rooms, but excludes manholes and isolated transformer vaults on private premises. (See definition 49.)

3. *Electrical supply lines* means those conductors and their necessary supporting or containing structures which are located entirely outside of buildings and are used for transmitting a supply of electrical energy.

Does not include open wiring on buildings in yards or similar locations where spans are less than 20 feet, and all the precautions required for stations or utilization equipment, as the case may be, are observed.

Railway signal lines of more than 400 volts to ground are always supply lines within the meaning of these rules, and of less than 400 volts may be considered as supply lines, if so run and operated throughout.

4. *Signal lines* means the conductors and their supporting or containing structures which are located outside of buildings and are used for public or private signal or communication service and which operate at not exceeding 400 volts to ground or 750 volts between any two points of the circuit and the transmitted power of which does not exceed 150 watts. When operating at less than 150 volts, no limit is placed on the capacity of the system.

Telephone, telegraph, messenger-call, clock, fire, or police alarm, and other systems conforming with the above are included.

Lines used for signaling purposes, but not included under the above definition, are considered as supply lines of the same voltage and are to be so run.

Exception is made under certain conditions for signal lines used in the operation of supply lines. (See rule 289.)

5. *Utilization equipment* means equipment, devices, and connected wiring which utilize electrical energy for mechanical, chemical, heating, lighting, testing, or similar purposes and are not a part of supply equipment, supply lines, or signal lines.

6. *Voltage* or *volts* means the highest effective voltage between any two conductors of the circuit concerned, except that in grounded multiwire circuits, not exceeding 750 volts between outer conductors, it means the highest effective voltage between any wire of the circuit and the ground.

In ungrounded circuits not exceeding 750 volts voltage to ground means the voltage of the circuit.

When one circuit is directly connected to another circuit of higher voltage (as in the case of an autotransformer), both are considered as of the higher voltage, unless the circuit of lower voltage is permanently grounded. Direct connection implies electrical connection as distinguished from connection merely through electromagnetic or electrostatic induction.

7. *Circuit* means a conductor or system of conductors through which an electric current is intended to flow.

8. *Grounded* means connected to earth or to some extended conducting body which serves instead of the earth, whether the connection is intentional or accidental.

9. *Grounded system* means a system having a permanent and effective electrical connection to earth. This ground connection may be at one or more points.

"Effective," as herein used, means a connection to earth of sufficiently low resistance and high current-carrying capacity to prevent any current in the ground wire from causing a harmful voltage to exist between the grounded conductors and neighboring exposed conducting surfaces which are in good contact with the earth, or with neighboring surfaces of the earth itself, under the most severe conditions which are liable to arise in practice.

10. *Permanently grounded* means having such an effective connection to the earth (by use of an underground system of metallic pipe mains or other suitable means), as described in the preceding paragraph.

11. *Current-carrying part* means a part intended to be connected in an electric circuit to a source of voltage. Non-current-carrying parts are those not intended to be so connected.

12. *Alive* or *live* means electrically connected to a source of potential difference, or electrically charged so as to have a potential different from that of the earth. The term "live" is sometimes used in place of the term "current-carrying," where the intent is clear, to avoid repetitions of the longer term.

13. *Dead* means free from any electrical connection to a source of potential difference and from electric charge; not having a potential different from that of the earth. The term is used only with reference to current-carrying parts which are sometimes alive.

14. *Manual* means capable of being operated by personal intervention.

15. *Automatic* means self-acting, operating by its own mechanism when actuated by some impersonal influence—as, for example, a change in current strength. Not manual, without personal intervention. Remote control that requires personal intervention is not automatic, but manual.

16. *Low-voltage protection* means the effect of a device operative on the reduction or failure of voltage to cause and

maintain the interruption of power supply to the equipment protected.

17 *Low-voltage release* means the effect of a device operative on the reduction or failure of voltage to cause the interruption of power supply to the equipment, but not preventing the reestablishment of the power supply on return of voltage.

18. *Switch* means a device for opening and closing or for changing the connection of a circuit. In these rules a switch will always be understood to be manually operated, unless otherwise stated.

19. *Disconnector* means a switch which is intended to open a circuit only after the load has been thrown off by some other means.

Manual switches designed for opening loaded circuits are usually installed in circuit with disconnectors, to provide a safe means for opening the circuit under load.

20. *Circuit-breaker* means a device designed to open under abnormal conditions a current-carrying circuit without injury to itself. The term as used in this code applies only to the automatic type designed to trip on a predetermined overload of current.

21. *Substantial* means so constructed and arranged as to be of adequate strength and durability for the service to be performed under the prevailing conditions.

22. *Qualified* means familiar with the construction and operation of the apparatus and the hazards involved.

23. *Guarded* means covered, shielded, fenced, inclosed, or otherwise protected, by means of suitable covers or casings, barrier rails or screens, mats or platforms, to remove the liability of dangerous contact or approach by persons or objects to a point of danger.

24. *Isolated* means that an object is not readily accessible to persons unless special means for access are used.

25. *Isolation by elevation* means elevated sufficiently so that persons may safely walk underneath.

26. *Exposed* (applied to circuits or lines) means in such a position that in case of failure of supports or insulation contact with another circuit or line may result.

Exposed (applied to equipment) means that an object or device can be inadvertently touched or approached nearer than a safe distance by any person. It is applied to objects not suitably guarded or isolated.

27. *Insulated* means separated from other conducting surfaces by a dielectric substance or air space permanently offering a high resistance to the passage of current and to disruptive discharge through the substance or space.

When any object is said to be insulated, it is understood to be insulated in suitable manner for the conditions to which it is subjected. Otherwise, it is, within the purpose of these rules, uninsulated. Insulating covering of conductors is one means for making the conductors insulated.

28. *Insulating* (where applied to the covering of a conductor, or to clothing, guards, rods, and other safety devices) means that a device, when interposed between a person and current-carrying parts, protects the person making use of it against electric shock from the current-carrying parts with which the device is intended to be used; the opposite of conducting.

29. *Explosion proof* means capable of withstanding without injury and without transmitting flame to the outside any explosion of gas which may occur within.

30. *Inclosed* means surrounded by a case which will prevent accidental contact of a person with live parts. A solid inclosure means one which will neither admit accumulations of flyings or dust, nor transmit sparks or flying particles to the accumulations outside.

31. *Conductor* means a metallic conducting material, usually in the form of a wire or cable, suitable for carrying an electric current. Does not include bus bars.

32. *Line conductor* means one of the wires or cables carrying electric current, supported by poles, towers, or other structures, but not including vertical or lateral connecting wires.

33. *Open lines* means overhead lines not in conduits, and consisting of single conductors or of individual twisted pairs, as opposed to multiple-conductor cables.

34. *Service* means the connecting conductors by which a supply of electrical energy is carried from a supply line to the building or premises served.

35. *Lateral conductor* means, in pole wiring work, a wire or cable extending in a general horizontal direction approximately at right angles to the general direction of the line conductors.

36. *Vertical conductor* means, in pole wiring work, a wire or cable extending in an approximately vertical direction.

37. *Normal sag* means the difference in elevation between the highest point of support of a span and the lowest point of the conductor in the span (or in the curve of the conductor in the span produced), at 60° F, with no wind loading.

38. *Apparent sag of a span* means the maximum departure of the wire in a given span from the straight line between the two points of support of the span, at 60° F, with no wind loading. Where the two supports are at the same level this will be the normal sag.

39. *Apparent sag at any point* means the departure of the wire at the particular point in the span from the straight line between the two points of support of the span, at 60° F, with no wind loading.

40. *Climbing space* means the vertical space reserved along the side of a pole structure to permit ready access for linemen to equipment and lines located on the pole structure.

41. *Lateral working space* means the space reserved for working between conductor levels outside the climbing space, and to its right and left.

14112°—21——2

42. *Conflicting or in conflict* (as applied to a pole line) means that the line is so situated with respect to a second line (except at crossings) that the overturning of the first line will result in contact between its poles or conductors and the conductors of the second line, assuming that no conductors are broken in either line: *Provided, however,* That lines on opposite sides of a highway, street, or alley are not considered as conflicting if separated by a distance not less than 60 per cent of the height of the taller pole line, but in no case less than 20 feet.

43. *Joint use* means simultaneous use by two or more kinds of utilities.

44. *Common use* means simultaneous use by two or more utilities of the same kind.

45. *Duct* means (in underground work) a single tubular runway for underground cables.

46. *Conduit* means (in underground work) a group of any number of ducts for underground cables.

Conduit means (in overhead or interior work) a tube or duct especially constructed for the purpose of inclosing electrical conductors.

47. *Manhole* (more accurately termed *splicing chamber* or *cable vault*) means an opening in an underground system which workmen or others may enter for the purpose of installing cables, transformers, junction boxes, and other devices, and for making connections and tests.

48. *Handhole* means an opening in an underground system into which workmen reach but do not enter.

49. *Transformer vault* means an isolated, fireproof inclosure, either above or below ground, in which transformers, and the devices necessary for their operation, are installed, and which is not continuously under attendance during operation.

50. *Reconstruction* means replacement of any portion of an existing installation by new equipment or construction. Does not include ordinary maintenance replacements.

51. *Urban districts* means thickly settled communities (whether in cities or suburbs) where congested traffic often occurs. A highway, even though in the country, on which the traffic is often very heavy, is considered as urban.

52. *Rural districts* means all places not urban, usually in the country, but in some cases within city limits.

53. *Wire gages:* The American Wire Gage (A. W. G.), otherwise known as Brown & Sharpe (B. & S.), is the standard gage for copper, aluminum, and other conductors, excepting steel, for which the Steel Wire Gage (Stl. W. G.) is used throughout these rules.

54. *Switchboard* means a large single panel, frame or assembly of panels on which are mounted (on the face or back or both) switches, fuses, busses, and usually instruments.

55. *Panelboard* means a single panel containing busses, fuses, and switches to control lights, fan motors, and similar devices of small individual as well as aggregate capacity, placed in or against a wall or partition and accessible only from the front.

56. *Raceway* means any channel for loosely holding wires or cables in interior work, which is designed expressly and used solely for this purpose. Raceways may be of metal, wood, or insulating material, and the term includes wooden and metal moldings consisting of a backing and capping and also metal ducts into which wires are to be pulled.

57. *Tags* means "Men at Work" tags of distinctive appearance, indicating that the equipment or lines so marked are being worked on.

SEC. 9. RULES COVERING METHODS OF PROTECTIVE GROUNDING OF CIRCUITS, EQUIPMENT, AND LIGHTNING ARRESTERS FOR STATIONS, LINES, AND UTILIZATION EQUIPMENT

CONTENTS

90. Scope of the Rules

The following rules apply to the grounding of all lightning arresters except those on signal circuits, and of all circuits, equipment, or wire runways when the grounding is intended to be a permanent and effective protective measure.

They do not apply to the grounded return of electric railways, nor to the grounding of lightning protection wires which are independent of electric circuits or equipment.

These rules do not require that grounding shall be done but cover the methods for protective grounding. The rules requiring grounding, in accordance with the methods specified below, are included under parts 1, 2, 3, and 4 of the National Electrical Safety Code.

Other methods of construction and installation than those specified in the rules may be used as experiments to obtain information, if done where supervision can be given by the proper administrative authority.

91. Application of the Rules

(*a*) *Waiving of Rules.*—The rules are intended to apply to all installations except as modified or waived by the proper administrative authority or its authorized agents, and are intended to be so modified or waived in particular cases whenever any rules are shown to involve expense not justified by the protection secured, or for any other reason are shown to be impracticable, or whenever it is shown that equivalent or safer construction can be more readily provided in other ways.

(*b*) *Application.*—The intent of the rules will be realized (1) by applying the rules in full to all new installations, reconstructions, and extensions, except where any rule is shown to be impracticable for special reasons or where the advantage of uniformity with existing construction is greater than the advantage of construction in compliance with the rules, providing the existing construction is reasonably safe; (2) by placing grounds on existing installations or bringing present grounds into compliance with the rules, except where the expense involved is not justifiable.

The time allowed for bringing existing installations into compliance with the rules will be determined by the proper administrative authority.

(*c*) *Temporary Installations.*—It will sometimes be necessary to modify or waive certain of the rules in cases of temporary installations or installations which are shortly to be dismantled or reconstructed.

(*d*) *Emergency.*—In cases of emergency or pending decision of the administrator the person responsible for the installation may decide as to modification or waiver of any rule, subject to review by proper authority.

92. Point of Attachment of Ground Conductor

(a) *Direct-Current Distribution Systems.*—In three-wire direct-current systems the ground connection shall be made on the neutral at one or more supply stations.

In two-wire direct-current systems the ground connection shall be made at one station only.

No ground connection shall be made at individual services or within the building served. In two-wire systems the grounded side of the circuit shall be insulated from ground except at the station ground connection.

(b) *Alternating-Current Distribution Systems.*—In alternating-current systems the ground connection shall be made at the building service or near the transformer (or transformers) either by direct ground connection (through water-piping system or artificial ground, see rule 94) or by the use of a system ground wire to which are connected the grounded conductors of many secondary mains and which is itself effectually grounded at intervals that will fulfill, for any secondary utilizing the system ground wire, the resistance and current-carrying requirements of rule 96.

When the secondaries of transformers are supplying a common set of mains, fuses, if installed, shall be located only at such points as not to cause the loss of the ground connections after any fuses in the transformer circuits or mains have been blown.

Alternating-current secondary circuits supplied from a transformer outside the building shall not be grounded inside buildings except at the service entrance.

In single-phase, three-wire systems the ground shall be on the neutral conductor. In single-phase two-wire systems the ground may be made on either conductor. In two-wire single-phase and in two or three-phase systems the ground shall be made at that point of the system which brings about the lowest voltage from ground of unguarded current-carrying parts of connected devices. Where one phase of a two or three-phase system is used for lighting, that phase should be grounded and at the neutral conductor, if one is used.

In the absence of direct grounds at all building services, ground connections shall be made to the grounded neutral or other grounded conductor of a secondary system supplying more than one utilization equipment, at intervals that will fulfill the resistance and current-carrying requirements of rule 96 (*a*).

(*c*) *Current in Ground Conductor.*—Grounds shall be so arranged that under normal conditions of service there will be no objectionable flow of current over the ground conductor.

Where the objectionable flow of current over a ground conductor is due to the use of multiple grounds, one or more of such grounds shall be abandoned or the location changed.

(*d*) *Equipment and Wire Runways.*—For conduit, armored cable, metal raceways, generators, motors, transformers, and other equipment, the point at which the ground conductor is attached shall, if practicable, be readily accessible.

No separate ground conductor shall be required for non-current-carrying parts of equipment if grounded through the conduit, cable sheath, or metal raceway system of the building by means of standard lock nuts and bushings or by a separate bond between the equipment and the conduit, armored cable, or metal raceway system.

For conduit, armored cable, or metal raceways the ground connection must be as near as practicable to the point where the conductors in the conduit system concerned receive their supply.

(*e*) *Service Conduit.*—When the service conduit is grounded, its ground wire must be run directly from it to the ground connection. The interior conduit, armored cable, or metal raceways, if well bonded to the service conduit, grounded as provided in this rule, needs no additional ground connection.

93. Ground Conductor

(a) *Material and Continuity.*—In all cases the ground conductor shall be of copper or of other metal which will not corrode excessively under the existing conditions and, if practicable, shall be without joint or splice. If joints are unavoidable they shall be so made and maintained as to conform to the resistance and current-carrying capacity requirements of rule 96.

In no case shall a fuse or automatic circuit-breaker be inserted in the ground conductor or connection except in a ground connection from equipment where its operation will result in the automatic disconnection from all sources of energy of the circuit leads connected to equipment so grounded; no switch shall be so inserted except in plain sight, provided with distinctive marking and effectively isolated from unqualified persons. (See also rule 92 *b*, par. 2.)

For lightning arresters and ground detectors the ground conductor shall be as short and straight as practicable and free from sharp bends.

(b) *Size and Capacity.*—The ground conductor or conductors for grounding circuits shall have a combined current capacity sufficient to insure the continuity and continued effectiveness of the ground connection under conditions of excess current caused by accidental grounding of any normally ungrounded conductor of the circuit. No individual ground conductor for electrical circuits shall have current capacity less than that of a No. 6 A. W. G. copper wire, except that for additional grounds after the first of any circuit, smaller ground wires may be used provided that they are in no case smaller than No. 10 copper.

The ground conductor for a direct-current system shall have a current capacity not smaller than the largest feeder of the same system leaving the station.

The ground conductor for alternating-current systems shall have a current capacity not less than one-fifth that of the conductor to which it is attached, except that it need not be larger than No. 0 A. W. G. copper.

For lightning arresters the ground conductor or conductors shall have a current capacity sufficient to insure continuity and continued effectiveness of the ground connection under conditions of excess current caused by or following discharge of the arrester. No individual ground conductor shall have less conductance than a No. 6 A. W. G. copper wire. For non-current-carrying parts of electrical equipment the conductance of a ground conductor shall be not less than that provided by a copper wire of the size indicated in the following table. When there is no fuse or automatic circuit-breaker protecting the equipment, the size of the ground conductor will be determined by the design and operating conditions of the circuit.

Rating of fuse which protects equipment:	Required size of ground conductor, A. W. G.
200 to 500 amperes	4
100 to 200 amperes	6
30 to 100 amperes	10
0 to 30 amperes	14

In portable cord to portable equipment protected by fuses not greater than 10-ampere capacity, a No. 18 ground wire may be used.

Ground wires for conduit, armored-cable, or metal-raceway systems must have a conductance at least equivalent to No. 10 A. W. G. copper (where largest wire contained is not larger than No. 0) and need not be larger than No. 4 (where the largest wire contained is larger than No. 0), and for service conduit the ground wire must have a conductance not less than that of No. 6 copper wire.

(c) *Mechanical Protection and Guarding against Contact.*—Where exposed to mechanical injury the ground conductor shall be protected by substantial conduit or other guard.

Guards for lightning-arrester ground conductors shall be of nonmagnetic material unless the ground conductor is electrically connected to both ends of the guard.

If the resistance of the ground connection is in excess of the values in rule 96 for water-pipe grounds, the ground conductor, except in rural districts, shall be protected and guarded by being inclosed in insulating conduit or molding to protect persons from injury by coming in contact with it.

Such a high resistance may exist where artificial grounds are necessarily permitted in lieu of the preferable grounds to buried metallic water-piping systems.

Mechanical protection and insulating guards should extend for a distance of not less than 8 feet above any ground, platform, or floor from which ground conductors are accessible to the public. (See also rule 226 *e*.)

Insulating mechanical protection is advisable for single arrester grounds, even when the connection is made to a water-piping system, and has therefore a low resistance, since a single connection is liable to be accidentally broken.

Even where ground connections have a resistance not exceeding that specified in rule 96 and no guard is therefore provided (or as an additional protection to persons even where guards are used) artificial grounds may be arranged to minimize the potential gradient along the surface of the earth by use of radial connecting wires underneath the earth surface or by other suitable means.

A circuit ground conductor shall be guarded as required for current-carrying conductors of the circuit, unless the ground conductor is entirely outside buildings, has strength and current capacity not less than that of No. 6 A. W. G. copper wire, and the circuit is elsewhere grounded by other ground conductors; except that in stations substantial bare ground busses may be used.

(*d*) *Underground.*—Wires used for ground conductors, if laid underground, shall, unless otherwise mechanically protected, be laid slack to prevent their being readily broken, and shall have joints carefully painted or otherwise protected against corrosion.

94. Nature of Ground Connection

The ground connection shall be permanent and effective and be made as indicated below, but always to water-piping systems if available.

(*a*) *Piping Systems.*—For circuits, equipment, and arresters at supply stations, connections shall be made to all available active metallic underground water-piping systems between which no appreciable difference of potential normally exists, if the pipe is of sufficient capacity, and to one such system if appreciable differences of potential do exist between them. At other places connections shall be made to at least one such system, if available. Gas piping should not be used for grounding circuits.

The protective grounding of electrical circuits and equipment to water-pipe systems in accordance with these rules should always be permitted, since such grounding offers the most effective protection to life and property and is not injurious to the piping systems.

Ground connections from circuits should not be made to jointed piping within buildings except water piping.

(*b*) *Alternate Methods.*—Where underground metallic piping systems are not available, other methods which will secure the desired permanence and conductance may be permitted. In many cases metal well casings, local metal drainpipes, and similar buried metal structures of considerable extent will be available and may be used in lieu of extended buried water-piping systems.

In some cases ground connection may be made to the steel frame of a building containing the grounded circuits or equipment, to which frames of machines and other noncurrent-carrying surfaces should also then be connected. In such cases the building frame should be itself well grounded by effective connection to the ground. This may require arti-

(*b*) *Ground Clamps*.—The ground connection to metallic-piping systems should be made by means of an approved clamp firmly bolted to the pipe after all rust and scale have been removed, or by means of a brass plug which has been tightly screwed into a pipe fitting or, where the pipe is of sufficient thickness, screwed into a hole in the pipe itself, or by other equivalent means.

The ground conductor must be attached to the clamp or to the plug by means of solder or by an approved solderless connector. The point of connection should be as readily accessible as possible, and the position should be recorded.

With bell-and-spigot-joint pipe it may be necessary to connect to several lengths where circuits or equipment of large current capacity are being grounded.

(*c*) *Contact Surfaces*.—If conduit, couplings, or fittings having protective coating of nonconducting material, such as enamel, are used, such coating shall be thoroughly removed from threads of both couplings and conduit and such surfaces of fittings where the conduit or ground clamp is secured, in order to obtain the requisite good connection. Grounded pipes shall be free from rust, scale, etc., at the place of attachment of ground clamp.

The armor of conduits, cables, metal raceways, and gas pipes shall be securely fastened in outlet boxes, junction boxes, and cabinets, so as to secure good electrical connection.

In ice houses, packing plants, etc., where a great deal of moisture is present and where conduits are attached to metal cabinets, cut-out, pull or junction boxes, compensators, etc., by means of standard lock nuts and bushings, these conduits should be bonded together with approved ground clamps.

(*d*) *Artificial Grounds*.—Artificial grounds should be located where practicable below permanent moisture level or, failing this, at least 6 feet deep. Each ground should present not less than 2 square feet surface to exterior soil. Areas where ground water level is close to the surface should be used when available

Where facilities are not available for determining the resistance of the ground connection (see rule 96), the exposed surface should be not less than 4 square feet.

Where copper ground plates are used, they should be at least 0.06 inch thick. When driven pipes are used, they should be of galvanized iron and not smaller than 1 inch internal diameter, and when cast-iron plates are used they should be at least 0.25 inch thick.

96. Ground Resistance

(*a*) *Limits.*—It is recommended that the combined resistance of the ground wires and connections of any grounded circuit, equipment, or lightning arrester should not exceed the values given below:

The current stated opposite the different resistances in the table is either the current capacity of a circuit from which leakage can occur to the grounded circuit, or the continuous current capacity to which the grounded equipment or arrester is limited by design or by automatic circuit-breakers or fuses.

Where a secondary is exposed only through transformer windings, this current capacity will be that of the primary fuse of the transformer. Where the secondary is exposed by the conductors of conflicting or crossing high-voltage circuits, the current capacities will be those of the automatic devices in such circuits.

Amperes	Water-pipe grounds	Artificial grounds, ordinary soils
	Ohms	Ohms
Less than 10	15	25
10 to 25	6	25
25 or more	3	25

The product of the corresponding numbers in the first and second columns is never greater than 150—that is, the potential difference due to the stated current is never greater than 150 volts—where connections are made to water pipes.

Where more than one ground is made on the same circuit, equipment, or arrester, in the same vicinity, all such grounds are considered collectively in respect to meeting the requirements of this rule.

Where because of dry or other high-resistance soils it is impracticable with artificial grounds to obtain resistances as low as the values given above for ordinary soils, two grounds as defined in rule 95 (*d*) should be provided, except as in rule 94 (*c*–2), and no requirement will be made as to resistance.

(*b*) *Checking.*—The resistance of station grounds should be checked when made.

With artificial grounds this check may be made by measuring the voltage between the grounded point of the circuit, or the grounded frame of the equipment, or the grounded point of the lightning arrester, and an auxiliary metal reference rod or pipe driven into the ground while a measured current is flowing through the ground connection and any exposed metal piping or other artificial ground not less than 20 feet distant.

If the station ground is to water piping, the check may be made with current flowing through the water piping and some independent piping system or artificial ground not less than 20 feet distant.

The auxiliary rod or pipe should be at least 10 feet from any artificial ground or piping systems through which the measured current is made to flow.

All ground connections shall be inspected periodically.

Ground connections on distribution circuits should, when installed, be tested for resistance unless multiple grounding to water-piping systems is used.

97. Separate Ground Conductors and Grounds

(*a*) *Ground Conductors.*—Ground conductors should be run separately to the ground (or to a sufficiently heavy grounding bus or system ground cable which is well connected to ground at more than one place) from equipment and circuits of each of the following classes:

(1) Lightning arresters.

(2) Secondaries connected to low-voltage lighting or power circuits.

(3) Secondaries of current and potential instrument transformers and cases of instruments on these secondaries.

(4). Frames of direct-current railway equipment and of equipment operating in excess of 750 volts.

(5) Frames of utilization equipment or wire runways other than covered by item (4).

(6) Lightning rods.

(*b*) *Arrester Grounds.*—Lightning-arrester ground connections shall not be made to the same artificial ground (driven pipes or buried plates) as circuits or equipment, but should be well spaced and, where practicable, at least 20 feet from other artificial grounds.

14112°—21——3

PART 1. RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRICAL SUPPLY STATIONS AND EQUIPMENT

CONTENTS

SEC. 10. PROTECTIVE ARRANGEMENTS OF STATIONS AND SUBSTATIONS

100. Scope of the Rules

The following rules apply to the electrical supply equipment of indoor and outdoor stations and substations. They also apply to similar equipment, including generators, motors, storage batteries, transformers, and lightning arresters when installed in factories, mercantile establishments, vehicles, or elsewhere, provided the equipment is in separate rooms or inclosures, under control of properly qualified persons, if the interiors of such rooms or inclosures are accessible only to such persons.

101. Application of the Rules and Exemptions

(*a*) *Application and Waiver of Rules.*—The rules are intended to apply to all such installations, except as modified or waived by the proper administrative authority or its authorized agents. They are intended to be so modified or waived in particular cases whenever the rules are shown to involve expense not justified by the protection secured, or for any other reason to be impracticable; or whenever it is shown that equivalent or safer construction can be more readily provided in other ways.

Other methods of construction and installation than those specified in the rules may also be made as experiments to obtain information, if done where supervision can be given by the proper administrative authority.

(*b*) *Intent of Rules.*—The intent of the rules will be realized (1) by applying the rules in full to all new installations, reconstructions, and extensions, except where the rule is shown to be impracticable for special reasons or where the advantage of uniformity with existing construction is greater than the advantage of construction in compliance with the rules, provided the existing installation is reasonably safe; (2) by placing guards on existing installations or otherwise bringing them into compliance with the rules, except where the expense involved is not justifiable.

The time allowed for bringing existing installations into compliance with the rules will be determined by the proper administrative authority.

(*c*) *Waiver for Temporary Installation.*—It will sometimes be necessary to modify or waive certain of the rules in cases of temporary installations or installations which are shortly to be dismantled or reconstructed.

(*d*) *Waiver in Emergencies.*—In cases of emergency or pending decision of the administrator, the person responsible for the installation may decide as to modifications or waiver of any rule, subject to review by proper authority.

102. General Requirements

(*a*) *Rooms and Spaces.*—All rooms or spaces in which electrical supply equipment is installed shall comply with the following requirements:

(1) *Fireproof Construction.*—They shall be, as far as practicable, noncombustible.

(2) *Storage and Manufacturing Processes.*—They shall be used neither for the storage of material nor for manufacturing processes causing hazard to electrical operators, except those materials or processes attendant upon the production or distribution of a supply of electrical energy.

(3) *Hazardous Conditions.*—They shall, if practicable, be free from flyings, inflammable gas, and acid fumes, in dangerous quantities. (For battery rooms, see section 13; for auxiliary equipment in hazardous locations, see rule 117.)

(4) *Ventilation.*—They should be well ventilated.

(5) *Moisture and Weather.*—They should be dry. In outdoor stations or stations in wet tunnels or subways, all live parts of equipment should be inclosed in weatherproof cases, unless the equipment is suitably designed to withstand the prevailing atmospheric conditions.

(*b*) *Rotating Machinery.*—Rotating machinery shall be installed upon suitable supports or foundations and if necessary secured in place.

103. Illumination

(*a*) *Under Normal Conditions.*—Rooms and spaces where electrical apparatus or machinery is located shall have means for adequate artificial illumination in accordance with good modern practice. This means of illumination shall be maintained ready for use at all times.

Illumination intensities recommended by the Illuminating Engineering Society are given in the discussion.

It is not intended that this rule should require permanent lighting in switch cells and similar small spaces occupied by electrical apparatus where permanent lighting is impracticable.

(*b*) *Emergency Source.*—A separate emergency source of illumination, from an independent generator, storage battery, gas main, lanterns (the latter two should never be used in battery rooms), or other suitable source, shall be provided in every station where an attendant is located.

104. Inclosing Walls and Ceilings

(*a*) *Walls.*—Rooms and spaces shall be so arranged with fences, screens, partitions, or walls as to prevent entrance of unauthorized persons or interference by them with equipment inside, and entrances not under observation of an authorized attendant shall be kept locked. Signs prohibiting entrance to unauthorized persons shall be displayed at entrances.

(*b*) *Ceilings.*—Above all equipment substantial roofs or ceilings shall be provided, except above equipment where such portions as would be injured by rains or by flying or falling objects are suitably inclosed or guarded to prevent such damage.

105. Floors, Floor Openings, Passageways, Stairs

(*a*) *Floors.*—Floors shall have even surfaces and afford secure footing. Projecting nails, loose boards, uneven or greasy wood floors, and slippery floors should be avoided.

Otherwise slippery floors or stairs should be provided with antislip treads.

(*b*) *Passageways.*—Passageways (including stairways) and working spaces shall be unobstructed, and (except such as are used solely for infrequent inspection, construction, and repair) shall, where possible, provide at least 6.5 feet headroom. (See rule 114 for working space.)

(*c*) *Railings.*—All floor openings over 18 inches deep and raised platforms over 4 feet high shall be provided with suitable railings.

Except for loading platforms, such rails are recommended where height exceeds 18 inches, especially where they are adjacent to live or moving parts or the working space on the platform is restricted.

(*d*) *Stair Guards.*—All stairways consisting of four or more risers shall be provided with handrails.

For very long and steep stairs occasional landings or turns are recommended.

(*e*) *Continuity.*—The heads of permanent ladders shall be provided with guards such as gates or sliding pipe sections whenever the heading breaks the continuity of a railing adjacent to working space.

For very long ladders occasional landings, turns, or safety loops are recommended.

(*f*) *Floor Toe Boards.*—All floor openings over 6 feet deep, and the edges of all raised platforms over 6 feet high, shall, where possible, be provided with suitable toe boards.

(g) *Stair Toe Boards.*—Toe boards shall, where practicable, be arranged at back of stairway treads where over exposed live or moving parts or over working spaces, passageways, or other stairways.

106. Exits

(a) *Clear Exits.*—Each room or space and each working space about equipment shall have suitable means of exit which shall be kept clear of all obstructions.

(b) *Double Exits.*—If the plan of the room or space and the character and arrangement of equipment are such that an accident would be liable to close or make inaccessible a single exit, as in the case of long narrow rooms, platforms, passageways, spaces behind switchboards, or wire and pipe tunnels, a second exit shall, if practicable, be provided.

107. Fire-Fighting Appliances

(a) *Fire Extinguishers.*—Each room or space where an operator is in attendance shall be provided with adequate approved fire-extinguishing appliances conveniently located and conspicuously marked. Any such appliances which have not been approved by Underwriters' Laboratories for use on live parts should be plainly and conspicuously marked with a warning to that effect.

(b) *Temperature Conditions.*—Fire extinguishers shall not be installed in locations subject to conditions of high or low temperature which will reduce their effectiveness.

Tetrachloride extinguishers are not affected by temperatures below 60° C (140° F) and above minus 40° C (—40° F).

108. Oil-Filled Apparatus

(a) *Indoors.*—Where practicable, indoor apparatus containing oil, such as transformers, switches, induction regulators, and lightning arresters, should be isolated from other kinds of equipment and provided with oil sills or other devices designed to retain escaping oil. Whenever located on balconies or containing large quantities of oil, this should always be done in the case of circuit-breakers and switches.

Drainage for escaping oil should be provided where practicable.

Such apparatus, if in large groups, or containing large total amounts of oil, should, where practicable, be installed in fire-resistive inclosures, well ventilated to outside of building to prevent dangerous accumulations of oil vapors, free from apparatus likely to take fire from burning oil, subdivided to a reasonable extent and having doors or windows so located or arranged that burning oil would not be liable to pass through to inflammable material or apparatus outside the inclosure.

(*b*) *Outdoors.*—When oil-filled apparatus is installed outdoors near building walls, these walls should preferably be of fire-resistive construction and should have doors or windows so located and arranged that burning oil is not liable to pass through them to inflammable material or apparatus.

SEC. 11. PROTECTIVE ARRANGEMENTS OF EQUIPMENT

110. General Requirement

All electrical supply equipment shall be of such construction and so installed and maintained as to reduce the life hazard as far as practicable.

111. Inspections

(*a*) *Regular Equipment.*—Electrical supply equipment shall comply with these safety rules when placed in service, and shall thereafter be periodically cleaned and inspected. Defective equipment shall be put in good order or permanently disconnected. Defective wiring, when hazardous, shall be repaired or removed.

(*b*) *Idle Equipment.*—Infrequently used equipment or wiring maintained for future service should be thoroughly inspected before use to determine its fitness for service.

(*c*) *Emergency Equipment.*—Equipment or wiring maintained for emergency service should be periodically inspected and, where necessary to determine its fitness for service, tested.

112. Guarding Shaft Ends, Pulleys, and Belts, and Suddenly Moving Parts

(a) *Revolving and Moving Parts.*—Pulleys, belts, chains, and shaft ends projecting through bearings, revolving fields, and other moving parts shall either be entirely inclosed in suitable casings, or otherwise adequately guarded by rails or barriers, where persons would be liable to be injured by those parts.

(b) *Suddenly Moving Parts.*—Parts of equipment which move suddenly, in such a way that persons in the vicinity are liable to be injured by being struck, such as handles and levers of circuit-breakers, shall be guarded or isolated.

113. Protective Grounding

(a) *Grounding Method.*—All grounding which is intended to be a permanent and effective protective measure, such as lightning-arrester grounding, grounding of circuits, equipment, or wire runways, shall be made in accordance with the methods specified in section 9, Method for Protective Grounding.

(b) *Grounding Noncurrent-Carrying Metal Parts.*—All electrical supply equipment, if operating at more than 150 volts to ground, or if in hazardous locations, shall have the exposed noncurrent-carrying metal parts, such as frames of generators and switchboards, cases of transformers, lightning arresters and switches, and operating levers, permanently grounded.

It is recommended that exposed noncurrent-carrying parts of electrical apparatus operating at 150 volts or less to ground be permanently grounded.

It is recommended that all metallic guards (including rails, screens, etc.) about electrical supply equipment should be permanently grounded.

Except in hazardous locations exposed noncurrent-carrying parts of equipment operating at more than 150 volts to ground may be left ungrounded and either isolated, or guarded, or provided with insulating mats as required for live parts at the same voltage. Such isolation, guarding, or mats should be so arranged that persons can not inadvertently touch these parts while also touching a grounded surface.

Hazardous locations include those where dampness, acid fumes, explosives, inflammable gas, or flyings normally exist.

(c) *Grounding Equipment During Repairs.*—Electrical equipment or conductors normally operating at more than 750 volts, on or about which work is occasionally done while separated from a source of electrical energy by switches or disconnectors only, shall be provided with some means, such as switches, connectors, or readily accessible ground conductor for grounding them. (See operating rules of secs. 45 and 46.)

114. Working Space about Electrical Equipment

(a) *Where required.*—Adequate working space with secure footing shall be maintained about all electrical-supply equipment which requires adjustment or examination during operation. (See rule 105 *b* for headroom.)

Working spaces about exposed live parts of more than 300 volts to ground shall be made inaccessible to other than authorized attendants by the use of suitable barriers when necessary.

(b) *Arrangement and Dimensions.*—The spaces shall be so arranged as to give the authorized attendants ready access to all parts requiring attention, and shall, where practicable (except where used only for infrequent construction, inspection, and repair), provide the following minimum horizontal dimension of the working spaces in front of live parts when necessarily exposed:

(1) For parts on one side of more than 300 volts and not more than 750 volts to ground and no live or grounded parts on the other side of the working space, 2.5 feet.

(2) For parts on one side of more than 750 volts to ground and no live or grounded parts on the other side of the working space, 3 feet.

(3) For parts on one side of more than 300 volts and not more than 750 volts to ground and live or grounded parts on the other side of the working space, 3 feet.

(4) For parts on one side of more than 750 volts to ground and live or grounded parts on the other side of the working space, 5 feet.

(c) *Where Working Space Is not Provided.*—Where the working space about electrical equipment is less than that specified in rule 114 (b) above, suitable inclosures or barriers shall be provided to prevent inadvertent contact with live parts. If such inclosures must be opened or barriers removed while the parts they guard are alive, all surrounding floors shall be provided with suitable insulating platforms or mats, so placed that the operator can not readily touch the live parts without standing on the mat or platform.

(d) *Working Space about Occasionally Exposed Live Parts.*—Where busses, switches, fuses, and other current-carrying parts of more than 750 volts are ordinarily guarded by covers or by being placed in separate rooms, adequate working space shall be provided about the live parts (unless effectively isolated by elevation according to rule 116), so that when they are occasionally exposed the operator will not be required to bring any part of his body within the following horizontal distances:

Voltage of parts:	Distance in feet
750 to 7 500	1
7 500 to 30 000	2
30 000 to 50 000	3
50 000 to 75 000	4
75 000 to 100 000	5
More than 100 000	6

115. Guarding Live Parts

(a) *Where Required.*—Protection by inclosures, barriers, or mats shall be provided for persons near otherwise exposed ungrounded current-carrying parts of electrical supply equipment, including those which do not require adjustment or examination during operation (such as bus bars and other conductors or the terminals of generators and motors), operating at more than 300 volts to ground and not effectively isolated by elevation, as given below, except where these parts are away from passageways and working spaces, used for frequent construction, inspection, and repair, for which see rule 114 (*d*).

(*b*) *Guards.*—Where current-carrying parts of more than 7500 volts are otherwise exposed, inclosures or barriers shall be so arranged that persons can not inadvertently come in contact with them.

Where current-carrying parts between 750 and 7500 volts are otherwise exposed, inclosures or barriers shall, if practicable, be so arranged that persons can not inadvertently come in contact with them. Where the use of guards is impracticable, insulating floors, platforms or mats, affording good footing, shall be provided and arranged so that persons can not inadvertently come in contact with the current-carrying parts while standing upon any grounded surface (including floors not of insulating materials). In addition, suitable permanent insulating guards shall be provided where necessary, so that persons can not while touching the current-carrying parts at the same time inadvertently come in contact with other live parts or grounded parts.

Inclosures may consist of suitable casings or suitable insulating coverings. The insulating covering of conductors should be depended upon only when it is impracticable to install more suitable guards and then only when very substantial, thoroughly dry, and containing no noninsulating flame-proofing compound or oil-soaked rubber.

Barriers may consist of horizontal or vertical strips placed in front of current-carrying parts, or of closely spaced partitions between such parts, extending beyond the exposed sides of the current-carrying parts.

Where covers, casings, or barriers must at any time be removed while the parts which they guard are alive, they should be of insulating material or so arranged that they can not readily be brought in contact with the live parts.

Inclosing or barrier guards not of grounded metal should be of substantial material and spaced from the current-carrying parts not less than three times the needle-point sparking distance, at the voltage concerned, of the intervening air, oil, or other dielectric.

(*c*) *Mats.*—Where current-carrying parts between 300 and 750 volts are otherwise exposed (not isolated by elevation as in rule 116 below, or not guarded by inclosures or barriers as described in (*b*) above), insulating floors, platforms, or mats, affording good footing, shall be provided and arranged so that persons cannot inadvertently come in contact with the current-carrying parts while standing upon any ground surface (including floors not of insulating materials).

Mats may be of wood, held together by wood pins, or of cork matting, linoleum, or rubber. The material and construction should be suitable for the voltage concerned and for the prevailing conditions. If subject to moisture or to accumulation of conducting dust, flyings, or chips, mats should provide surfaces minimizing the hazards from these sources.

(*d*) *Bare Parts.*—Bare parts at different potentials shall be effectively separated. Such parts in circuits of large capacity or operating at more than 7500 volts shall, unless provided with inclosures or other guards specified in rule 114 (*c*), be provided with suitable barriers, if practicable, so that they will not be short-circuited by tools or other conducting objects.

116. Isolating Live Parts by Elevation (for Switchboards see rule 176c)

Current-carrying parts need not be guarded if the following distances above the floors which may be occupied by persons are maintained:

Voltage of conductors:	Elevation in feet
300 to 750	7.0
750 to 2 500	7.5
2 500 to 7 500	8.0
7 500 to 30 000	9.0
30 000 to 70 000	10.0
70 000 to 100 000	12.0
More than 100 000	14.0

117. Hazardous Locations and Deteriorating Agencies

(*a*) *Inclosure of Arcing and Heating Parts.*—In locations where inflammable gas or inflammable flyings normally exist in dangerous quantities all parts at which sparking or arcing is liable to occur, such as rheostats and resistance devices, shall be so inclosed as to reduce the hazard as far as practicable.

This inclosure shall be by one of the following methods:

(1) By placing in separate compartments or rooms.

(2) By using nonabsorptive noncombustible casings of the solidly inclosed type when inflammable dust or flyings are present.

(3) By using nonabsorptive noncombustible explosion-proof casings when inflammable gas exists in dangerous quantities.

(*b*) *Deteriorating Agencies.*—Suitable guards or inclosures shall be provided to protect exposed current-carrying parts, insulation of leads or electrical devices or equipment where susceptible to injury by being installed directly under rotating equipment or in other locations where dripping oil, excessive moisture, steam, vapors, or similar agents exist. (For battery rooms see rule 135.)

118. Identification

(*a*) *Equipment in General.*—Electrical supply equipment shall be suitably identified when necessary for safety. The identification may be by position, color, number, name plate, label, design, or other means, but the method of identification chosen shall be uniform throughout any one system. (See rule 164 *a* for switches.)

The voltage and intended use shall be shown when important.

Identification marks should not, if avoidable, be placed on removable covers or casings, such as instrument covers and disconnector compartment doors, where the interchanging of these removable parts might lead to accident.

(*b*) *Generators and Motors.*—Generators and motors shall each be provided with a name plate giving the maker's name, the rating, normal full-load speed, and the voltage.

SEC. 12. ROTATING EQUIPMENT

(This includes generators, motors, motor-generators, and converters.)

120. Speed-Control and Stopping Devices

(*a*) *Speed Limits for Prime Movers.*—Prime movers driving generating equipment shall be provided with automatic speed-limiting devices, where harmful overspeed can otherwise occur, in addition to their governors, if necessary, as with some types of steam turbines.

(*b*) *Stops for Rotating Equipment.*—Stopping devices, such as switches or valves which can be operated from locations convenient to machine operators, shall be provided for prime movers or motors driving generating equipment.

Devices which operate in such a way that the development of defects on their becoming inoperative will stop the units protected, should be used where practicable.

Controls to be used in emergency for machinery and electrical equipment should be so located as to permit operation with a minimum of danger during such emergency. (See rule 165 for fuses and circuit-breakers.)

(*c*) *Speed Limit for Motors.*—Machines of the following types shall be provided with speed-limiting devices unless the load and the mechanical connection thereto are of such a character as to safely limit the speed or unless the machine is always under the manual control of a qualified operator:

(1) Separately excited direct-current motors.

(2) Series motors.

(3) Motor-generators and converters which can be driven at excessive speed from the direct-current end, as by a reversal of current or decrease in load.

The required limitation of speed may be obtained by the use of a relay, centrifugal switch, or other similar device which will cut off the supply of energy when excessive speed is attained.

(*d*) *Low-Voltage Protection.*—All motors so employed or arranged that an unexpected starting of the motor is a hazard except those with an emergency use and where the opening of the circuit may cause a special hazard, such as exciter or condenser-pump motors, shall be equipped with low-voltage protection which will automatically open the motor circuit when the voltage falls below an operating value.

It is recommended that polyphase motors be so equipped as to prevent their operation upon failure of one or more of the supply phases.

(*e*) *Low-Voltage Releases.*—Where the speed control of direct-current motors is accomplished by varying the field resistance, and the nature of the load and the range of the field rheostat are such as to make a dangerous speed attainable and no speed-limit devices are used, the field rheostat shall be arranged with low-voltage releases or other devices so that the motor can not be started or continued in operation under dangerously weakened field except where the operation of such a device might result in serious injury to service or apparatus.

(*f*) *Protection of Control Circuits.*—Where speed-limiting or stopping devices are electrically operated the control circuits by which such devices are actuated shall be in conduit or otherwise suitably protected from mechanical injury, in accordance with rule 151.

121. Guards for Live Parts

(*a*) *Mats on Rotating Equipment.*—Suitable insulating mats or platforms of substantial construction and providing good footing shall be so placed on floors and, if necessary, on frames of machines having exposed live parts of more than 300 volts to ground, that operators can not readily touch such parts unless standing on the mat or platform.

(*b*) *Parts of More than 750 Volts.*—For parts of more than 750 volts, suitable inclosing or barrier guards shall, if practicable, be provided (in addition to mats or platforms), and so arranged that the operator can not inadvertently touch at the same time these live parts and any neighboring grounded parts.

(*c*) *Access to Live Parts.*—Where necessary, steps and handrails shall be installed on or about large machines to afford ready access to live parts which must be examined or adjusted during operation.

(*d*) *Frame Switches.*—Where switches are installed on the frames of generating equipment for the purpose of reducing inductive voltage in generator and converter field coils they shall be suitably constructed or guarded to prevent passers-by from inadvertently coming in contact with the live parts, to protect persons handling them, and to prevent their being accidentally opened or closed.

(*e*) *Arcing Shields.*—Suitable shields or barriers other than rails shall be provided where practicable to prevent arcing on large commutators or to prevent arcs that may occur from injuring persons in the vicinity as in the case of narrow working spaces located immediately above or beside such equipment.

It is recommended that where suitable shields have not been installed, goggles should be available.

122. Grounding Machine Frames

(*a*) *Grounding Machine Frames.*—All frames of rotating electrical equipment shall be permanently grounded except as permitted below and in rule 113.

(*b*) *Coupled Machines.*—Where two or more machines, either of which operates at more than 150 volts to ground, are mechanically coupled together and the operator can touch the frames of more than one at a time, the frames of all such shall be permanently grounded or bonded together electrically.

This rule may be waived with high-voltage series generator sets in existing installations where for operating reasons the generators must have their frames insulated from the ground and the motor frame is grounded, and where it is impracticable to place insulating barriers between the grounded and ungrounded frames.

(*c*) *Auxiliaries.*—Exciters and auxiliary circuits electrically connected to generators or other machines of more than 750 volts to ground (with frames ungrounded) shall be installed, protected, and identified as machines and circuits of the same voltage as that of the machine for which they are auxiliaries.

123. Terminal Bases and Bushings

(*a*) *Terminal Bases.*—Terminal bases, when used on motors or generators should preferably be of suitable noncombustible, nonabsorptive, insulating material, such as slate, marble, or porcelain.

(*b*) *Bushings.*—Bushings where used for wires coming through the frames of motors or generators should preferably be of porcelain, suitable composition material, or of hardwood properly filled, except that soft rubber may be used if not exposed to oils, grease, or other deleterious substances in such quantities as to cause their rapid destruction.

124. Deteriorating Agencies

(*a*) *Protection Required.*—Suitable guards or inclosures shall be provided to protect exposed current-carrying parts, insulation of leads, balance coils, or other electrical devices belonging to motors and generating equipment where installed directly under equipment or in other locations where dripping oil, excessive moisture, steam, vapors, or similar injurious agents exist.

(*b*) *Grounding.*—The metal frames and other exposed noncurrent-carrying metal parts of equipment in these locations shall be permanently grounded.

125. Motors

(*a*) *Starters.*—Starting apparatus should preferably be located in sight of the motor it controls.

(*b*) *Motors in Hazardous Locations.*—Motors with their auxiliary equipment, at which sparking or arcing or high temperature is liable to occur, when in rooms normally containing explosives, inflammable gas, or inflammable flyings, shall be so installed as to reduce the hazard by inclosure in an adequately ventilated separate compartment, by solidly inclosed or explosion-proof type of equipment, or, when protected against flyings only, by partitioning off a space or by a suitable boxing.

Motors should be protected from dust. Inclosed-type motors are recommended in dusty places, being preferable to boxing.

Where practicable, motors permanently located on wooden floors should be provided with suitable drip pans.

SEC. 13. STORAGE BATTERIES

The following rules (except 133) apply only to storage batteries exceeding 50 kilowatthours capacity at the eight-hour rate of discharge.

130. Isolation

Storage batteries shall be made inaccessible to other than properly qualified persons by being placed in a separate room or inclosure.

131. Ventilation

Rooms or inclosures containing storage batteries shall be so ventilated as to remove acid spray and prevent dangerous accumulation of inflammable gas.

The battery room ventilating system shall be so arranged as not to carry any gases therefrom into other rooms or spaces of the building where electrical apparatus or equipment is located.

Communication of drafts to other rooms should be prevented.

132. Suitable Supports and Floors

The cells, except small cells of insulating material set in sand trays, on shelves, or otherwise separated from the floors, shall be supported by suitable insulators, such as glass or thoroughly vitrified and glazed porcelain. Suitable drainage or other means shall be provided beneath cells to prevent the accumulation of electrolyte in case of leakage or spraying.

Acid-resistive floors, such as vitrified brick set in pitch, are recommended where large batteries are installed.

133. Guarding Live Parts in Battery Rooms

(a) *Separation of Parts of More than 150 Volts.*—The arrangement of cells and connections shall be such that any two current-carrying parts between which a voltage exceeding 150 exists shall be properly guarded if the parts are otherwise so exposed that persons are liable to make accidental contact with both at the same time.

(b) *Precaution Against Parts of More than 150 Volts.*—No conductor of more than 150 volts to ground shall be placed in any passageway, unless guarded or isolated by elevation.

134. Illumination

Storage-battery rooms should be lighted, if practicable, from outside lamps. Heating devices with open flames or exposed incandescent resistors shall not be installed.

If lamps are inside, only incandescent electric lamps in keyless porcelain or composition sockets, controlled from points not exposed to battery vapor, shall be used.

It is recommended that switches and incandescent lamps located in battery rooms be put in vapor-proof inclosures.

135. Acid-Resistive Coverings

Conductors in battery rooms, if of such material or so located as to be liable to corrosion, shall have suitable protective coverings or coatings, unless the ventilation is such as to render this unnecessary.

SEC. 14. TRANSFORMERS, INDUCTION REGULATORS, RHEOSTATS, GROUND DETECTORS, AND SIMILAR EQUIPMENT

140. Current-Transformer Secondary Circuits

(a) *Short-Circuiting.*—Secondary circuits of current transformers, including constant-current and instrument transformers (except those supplying relays only, or those having their primary circuits always disconnected before the secondary circuits are worked on), shall be provided with means for short-circuiting them which can be readily connected while the primary is energized and which are so arranged as to permit the removal of any instrument or other device from such circuits without opening the circuits.

(b) *Protection When of More than 7500 Volts.*—Where primaries are of more than 7500 volts, secondary circuits, unless otherwise adequately protected from injury or contact of persons, shall be in permanently grounded conduit.

141. Grounding Low-Voltage Circuits of Instrument Transformers

The low-voltage circuits of all instrument transformers shall be permanently grounded unless the circuits are installed, guarded, and plainly identified as required for the high-voltage circuits of the transformers, in accordance with rule 150.

This will sometimes require marking to distinguish such a low-voltage circuit from others with which it is associated, but which are protected by ground connections.

142. Grounding Transformer Cases

The metal case or exposed frame of each transformer, reactor, induction regulator, and similar equipment, which is located where dampness or inflammable gas normally exists, or which is connected to a circuit operating at more than 150 volts to ground, shall be permanently grounded.

Exception is permissible in accordance with rule 113 *b*, in locations free from inflammable gas, where the entire transformer is isolated or guarded as required for the highest-voltage circuit connected with the transformer, and is plainly and conspicuously identified as of that voltage.

143. Location and Arrangement of Transformers

Transformers shall be installed according to one of the following methods:

(1) On poles or (when permitted by local authority) on walls of buildings, and in compliance with the overhead line rules. (See rules 214 and 228.)

(2) In outdoor inclosures such that unauthorized persons can not, without special effort, come in contact with any part of the casings or wiring.

(3) In ventilated transformer vaults or rooms which shall be made inaccessible to unauthorized persons.

Where the amount of oil in transformer casings is considerable and the transformers are located in buildings used for other than station purposes, they should be placed in suitable transformer vaults.

(4) In rooms containing other equipment.

If in stations, such transformers should be isolated from other equipment and oil sills or suitable arrangements for draining should preferably be provided.

144. Resistance Devices

Rheostats shall be not less than 1 foot from combustible material or separated therefrom by a slab or panel of noncombustible nonabsorptive material of suitable thickness, not less than one-half inch, somewhat larger than the rheostat, and secured in place by bolts independently of the rheostat supports.

Rheostats or resistance devices shall not be placed where spattering molten metal due to high temperature in the rheostat may fall upon inflammable material or spaces frequently occupied by persons.

Rheostats or resistance devices exposed to excessive dust or flyings should preferably be installed in suitable cabinets or equipped with dust-proof side and face plates. (For installation in hazardous locations see rule 117.)

145. Ground Detectors

Every station supplying circuits which are not permanently grounded in accordance with section 9 shall be provided with one or more reliable means of ground detection which can be applied to determine the existence of a ground on any such circuit extending outside the station.

SEC. 15. CONDUCTORS

150. Electrical Protection

(a) *Fuses Required.*—Conductors shall be suitable for the location, use, and voltage. Conductors should be protected against excessive heating by the design of the system or by suitable fuses or automatic circuit-breakers except as provided in rule 165.

Automatic circuit-breakers may be set so as to interrupt the circuits only on excessive short-circuits, if constant attendance is provided and protection is thus also afforded by manual operation.

(*b*) *Fuses in Grounded Conductors.*—Conductors normally grounded for the protection of persons shall be arranged without fuses or automatic circuit-breakers interrupting their continuity between the source of electrical supply and the point at which the ground conductor is attached, unless the circuit-breaker opens all conductors of the circuit with one operation.

(*c*) *Circuits Exposed to Higher Voltages.*—If exposed through transformer windings or outdoor circuits to higher voltages, circuits of less than 750 volts shall be isolated or grounded unless placed in grounded conduit or other suitable duct or identified and guarded as required for conductors of the highest voltage to which they are exposed.

151. Mechanical and Thermal Protection

(*a*) *Protection against Injury.*—Where exposed to mechanical injury suitable casing, armor, or other means shall be employed to prevent injury or disturbance to conductors, their insulation, or supports.

(*b*) *Flame-Proofing.*—Where conductors with insulating coverings are closely grouped and any one is liable to damage from nearby conductors (as sometimes on the rear of switchboards or in cableways), they shall have a substantial flameproof outer covering.

Flame-proofing shall be stripped back on all conductors a sufficient distance from the terminals to give the necessary insulation for the voltage of the circuit on which the conductor is used.

(*c*) *Protection against Contact.*—Large conductors liable to be torn from their supports by the forces to which they are subjected (as by the magnetic fields produced) shall be so supported that they can not come in contact with the surfaces along which they are run if uninsulated or with other conductors and equipment.

This applies in particular to generator leads and conductors liable to large short-circuit currents.

(*d*) *Conductors between Generators and Outside Lines.*—Conductors between generators and outside lines shall be accessible and supported on approved noncombustible, nonabsorptive insulators or placed in approved cable, metal conduit, tile, or other fireproof ducts.

(*e*) *High Temperatures.*—Insulated conductors exposed to excessive temperatures shall have insulation which remains effective and does not rapidly deteriorate under such conditions.

152. Isolation

All conductors of more than 750 volts and ungrounded bare conductors of more than 300 volts to ground shall be isolated by elevation in accordance with rule 116, or guarded in accordance with rules 115 and 153, so that no person can inadvertently come in contact with them; provided that busses and bus structures and line connections thereto may be installed in accordance with rule 114, in suitable locations specially arranged for such purposes.

153. Guarding Conductors

(*a*) *Use of Inclosing Casings.*—Where insulated conductors are inclosed, suitable permanently grounded metal conduit or grounded metal sheathing shall be used; or in lieu thereof other ducts, runways, or compartments of tile, bituminized fiber, concrete, or other suitable fire-resistive materials may be used, if containing no exposed combustible material. In damp places, conduit, ducts, or runways shall be made waterproof and be provided with suitable means for draining off condensation, unless the conductors contained are lead-sheathed cables.

(*b*) *Conductors of More than 750 Volts in Conduit or Sheathing.*—Conductors operating at more than 750 volts (unless separately supported and effectively isolated by elevation or by inclosing in suitable compartments or screens, as in paragraph *d*), shall be suitable metal-sheathed cable, run in metal conduits or suitable fire-resistive ducts or compartments, with the metal sheathing permanently grounded. Other covering may be used in suitable grounded metal conduit or insulating duct, when installed in dry locations. The conduit or duct shall provide a smooth runway, with smooth outlets. Metal conduit, if used, shall be made electrically and mechanically continuous with the metal casings of all conduit fittings. If not exposed to moisture a metal sheath need not be continuous over splices, provided that the sheaths are suitably bonded together electrically around the splice by a conductor having current capacity not less then No. 6 A. W. G. copper.

(*c*) *Metal-Sheathed Cable Outlets of More than 750 Volts.*—The insulation of the several conductors of multiple-conductor cable, where leaving the metal sheath at outlets, shall be thoroughly protected from mechanical injury, moisture, and electrical strains by means of a pothead or equivalent method.

(*d*) *Open Conductors of More than 750 Volts.*—When any open insulated conductor of more than 750 volts, or any open bare conductor of more than 300 volts to ground, is necessarily brought closer to the floor line than the clearances required for isolation by elevation, they shall be guarded by permanent screens, by inclosing partitions, or by suitable barrier guards. Where barrier rails only are used, the surrounding floors shall be provided with suitable insulating platforms, mats, or covers.

It is recommended that even when at less than 300 volts to ground bare conductors should be guarded if not isolated by elevation, wherever liable to be short-circuited or grounded by conducting tools or other objects.

154. Guarding in Hazardous Locations

(*a*) *Conduit or Metal Sheath.*—Conductors in locations where inflammable gas normally exists shall be in metal conduit or metal-sheathed cable. All fittings and outlets of such conduit and cable shall be electrically and mechanically continuous with the conduit or metal sheath, and the conduit shall be sealed to prevent entrance of gases.

This rule does not apply to conductors of large cross section which obviously can not be placed in conduit, such as copper bars connecting large cells with end-cell switches.

(*b*) *Insulating Supports.*—Conductors in damp locations, if neither in conduit nor in waterproof metal sheaths in other suitable ducts, shall be effectively isolated and supported on a suitable type of insulator.

155. Lighting Fixtures

(*a*) *Fixtures and Pendants.*—Arrangements of permanent fixtures and plug receptacles shall be such that portable cords need not be brought into dangerous proximity to live or moving apparatus. All lamps shall be arranged to be controlled, replaced, or trimmed from safely accessible places.

Pendent conductors shall not be installed where they can be readily moved so as to bring them in contact with live parts of electrical supply equipment.

(*b*) *Attachment Plugs.*—Portable conductors shall be attached to fixed wiring only through separable attachment plugs which will disconnect all poles by one operation. (See sec. 37 for portables and pendants.)

156. Wiring for Illumination

Wiring installed for the illumination of the station should be installed and protected as required for similar utilization equipment and conductors in Part 3.

157. Temporary Wiring and Precautions During Construction

(*a*) *Special Protection.*—Temporary wiring which is not in compliance with these rules may be used when it is constantly under competent supervision or protected by suitable barrier guards and warning signs while it or neighboring wiring is alive and accessible to any person.

(*b*) *Construction Precautions.*—Where extensions or extensive changes are being made to stations already in operation the following special precautions shall be taken:

(1) All equipment and apparatus not designed for outdoor operation but temporarily exposed to the weather, or dust, dirt, and flyings incident to construction work shall be specially and adequately shielded against such influences, in so far as practicable.

(2) All equipment and apparatus shall be inclosed or isolated so as to be inaccessible to unauthorized persons, in so far as practicable, or it may be installed in accordance with Part 3.

158. Taping Ends and Joints

Ends and joints of insulated conductors, unless otherwise adequately guarded, shall have equal insulating covering with other portions of the conductor.

SEC. 16. FUSES, CIRCUIT-BREAKERS, SWITCHES, AND CONTROLLERS

160. Accessible and Indicating

(*a*) *Arrangement.*—All switches, fuses, automatic circuit-breakers, starting rheostats, and other control devices shall be readily and safely accessible to authorized persons, unless remotely controlled. They shall be so arranged or marked as to identify the equipment controlled by them, and (except fuses) shall indicate whether they are open or closed.

(*b*) *Accidental Closing.*—Switches shall be so installed as to minimize the danger of accidental operation, and where practicable so that gravity can not close them; such switches as may tend to close by gravity shall be provided with a proper latch or stop block to prevent accidental closing Where practicable, the blades of knife-switches should be dead when the switches are open.

161. Oil Switches

(*a*) *Isolation.*—Oil circuit-breakers and oil switches shall, wherever practicable, be isolated from other types of switches and other electrical apparatus and conform to rule 108. On circuits of more than 7500 volts they shall be operated by remote control.

Remote control may be of mechanical, electrical, or other type. It is not intended to prohibit the use of switches operated manually by means of levers or poles from a remote position.

162. Where Switches are Required

Suitable switches or circuit-breakers which may be manually operated shall be inserted in all leads (except a grounded conductor) to generators, motors, transformers (except instrument transformers), and all outgoing supply circuits, except as listed below.

Exceptions.—(1) In most cases the switch called for should be capable of opening the circuit under overloads. In some cases, as between generators and transformer banks used with them, disconnectors only would be required.

(2) Where two or more pieces of electrical supply equipment or supply lines are operated as a single unit no switch is necessarily required between them.

(3) Switches shall not be required in transformer vaults except as may be deemed necessary by the engineer in charge to meet operating requirements.

163. Switches or Other Grounding Devices

It is recommended that switches or other suitable means be provided, where practicable, to facilitate short-circuiting and grounding equipment or lines for which the operating rules (see secs. 45 and 46) require grounding to protect workmen. (See rule 113 *c*.)

164. Capacity of Switches and Disconnectors

(*a*) *Suitability.*—Switches used otherwise than as disconnectors shall be of suitable voltage and ampere rating for the circuit on which they are installed and should preferably be marked with the current which they can safely interrupt.

Disconnectors shall be of suitable voltage and ampere rating for the circuit on which they are installed.

It is recommended that disconnectors be marked with warning against opening when carrying load. Where a group of disconnectors is contained in one room or compartment a single conspicuous sign may be sufficient.

(*b*) *Locking.*—Remotely controlled switches, oil switches, and disconnectors shall be so arranged that they can be secured or blocked in the open position or plainly tagged to prevent careless closing while work is being done on equipment controlled by them.

For switches and disconnectors the accidental opening of which may cause hazard, similar arrangements are desirable for retaining them in closed position.

Locking is recommended rather than blocking wherever parts of equipment are remote from the point of control.

(*c*) *Air Break.*—Unless a switch operating on a circuit between 750 and 7500 volts makes an air break, it is recommended that there shall be installed between it and the source of energy supply a suitable air or oil-break disconnector or equivalent device having an air or oil gap suitable for the operating voltage of the circuit.

An air-break switch or air-break disconnector shall be inserted in each conductor between electrical supply equipment or lines and sources of energy of more than 7500 volts, if the equipment or lines may have to be worked on without protective grounding while the sources may be alive. (For lightning arresters see rule 181.)

(*d*) *Alignment.*—Knife switches shall maintain such alignment under service conditions that they can be closed with a single unhesitating motion.

165. Where Fuses or Automatic Circuit-Breakers are Required

(*a*) *Apparatus Leads.*—All circuit leads to motors, constant-potential generators, transformer primaries (except series transformers), and station auxiliaries, and all outgoing circuits shall, except as provided in (*b*) and (*c*) below, be protected from excessive current by suitable fuses or automatic circuit-breakers.

(*b*) *Electrically Driven Generators.*—A motor-driven generator or a rotary converter adequately protected from excessive load by fuses or automatic circuit-breakers in the motor leads or the primary supply leads need not have such devices in the generator or secondary leads.

(*c*) *Other Exceptions.*—No fuses or circuit-breakers are required in the following cases:

(1) Grounded conductors.

(2) Field-excitation circuits.

(3) Leads of alternating-current generators.

(4) Leads connecting two or more pieces of electrical supply equipment operated as a single unit.

(5) Circuits supplying interconnected three-wire systems of direct-current distribution.

(6) Circuits the opening of which may cause greater hazard to life or property through interruption of service.

166. Disconnection of Fuses Before Handling

Fuses in circuits of more than 150 volts to ground or more than 60 amperes shall be arranged in one of the following ways:

(*a*) So that the fuses are necessarily disconnected from all sources of electrical energy before they can be touched.

(*b*) So that the fuses can be disconnected from all sources of electrical energy by a suitable switch.

(*c*) So that the fuses can be conveniently handled by means of insulating handles or portable appliances provided for the purpose.

Circuits of less than 150 volts to ground and less than 60 amperes capacity are exempted from the provisions of this rule.

The use of insulating gloves and mats is permissible on circuits not exceeding 750 volts.

167. Arcing or Suddenly Moving Parts

(a) *Protection from Burns.*—Fuses and circuit-breakers shall, as far as possible, be so located and shielded that persons will not be burned by their operation.

(b) *Protection against Moving Parts.*—Handles or levers of circuit-breakers and similar parts which may move suddenly, in such a way that persons in the vicinity are liable to be injured by being struck by them, shall be guarded or isolated.

168. Grounding Noncurrent-Carrying Metal Parts

Exposed noncurrent-carrying metal parts of switch and fuse cases, levers, and other similar parts to which leakage is liable to occur from live parts, and thereby create a hazard, shall be permanently grounded in accordance with rule 113.

Minor parts, such as ferrules of knife switches, which are not liable to become alive, are excepted.

169. Guarding Live Parts of Switches, Fuses, and Automatic Circuit-Breakers

(a) *Of More than 750 Volts.*—All switches interrupting circuits of more than 750 volts shall be operated by means of remote control or lever mechanisms or be provided with suitable casings protecting the operator from danger of contact with current-carrying parts. The control devices for switches shall indicate whether switches are open or closed. Lever-operated, circuit-breaker-type switches should be equipped with indicating devices to show whether they are open or closed whenever the position of the handles does not do so. All fuses and automatic circuit-breakers not suitably isolated by elevation shall be of an incased type or be provided with suitable inclosures for all current-carrying parts.

14112°—21——5

Large-capacity, high-voltage oil switches should, where practicable, be placed away from the operator and operated by remote (or lever) control, since the blowing up of the oil containers may cause serious injuries to persons in the vicinity.

For the purpose of this rule voltages in excess of 750 will be included as not more than 750 where the excess is for purposes of regulation only.

(*b*) *Less than 750 Volts.*—All switches interrupting circuits of not more than 750 volts shall be operated by means of remote-control mechanisms or be encased during ordinary operation or be provided with insulating handles and insulating guard disks or shields, so arranged as to make it unlikely that the hand will come in contact with live parts.

Switches of not more than 300 volts to ground may be exempted from the above requirement.

(*c*) *Platforms or Mats.*—Where live parts of switches, fuses or circuit-breakers operating at more than 300 volts to ground are not remotely controlled, or provided with inclosing guards effective during ordinary operation or adjustment, or isolated by elevation, suitable insulating floors, mats, or platforms shall be provided on which the operator must stand while operating the switches or adjusting the fuses or automatic circuit-breakers in accordance with rule 115.

(*d*) *Disconnectors.*—In the case of disconnectors not isolated by elevation but guarded by barriers, the barriers shall extend beyond the disconnected parts when in any position.

SEC. 17. SWITCHBOARDS

170. Location and Accessibility

(*a*) *General Location.*—Switchboards shall, where practicable, be so placed that the operator will not be endangered by any live or moving parts of machinery or equipment located near the board.

They shall be so placed as to reduce to a minimum the danger of communicating fire to adjacent combustible material.

(*b*) *Spaces about Boards.*—The space back of the board shall be kept clear of rubbish and shall not be used for storage.

(*c*) *Accessibility.*—Switchboards shall be accessible to authorized operators from both sides when the connections are on the back (see rule 114 for working space), but may be placed against a wall when operating at not more than 750 volts with the wiring entirely on the face.

(*d*) *Arrangements.*—Switchboards shall have all switches so arranged that the points of control are readily accessible to the operator. Instruments, relays, and other devices requiring reading or adjustment shall be so placed that work can be readily performed from the working space.

171. Material and Illumination

(*a*) *Material.*—Switchboards shall be made of noncombustible material and be kept free from moisture.

(*b*) *Illumination.*—Sufficient illumination shall be provided both for the front and rear of the switchboard so that the switchboard may be readily operated and instruments conveniently read.

172. Necessary Equipment

Switchboards which control generating equipment or outgoing supply circuits shall (except in substations without regular attendance) be equipped with such instruments as are necessary to show operating conditions. (See rule 145 for ground detectors.)

173. Arrangement and Identification

Connections, wiring, and equipment of switchboards and panelboards shall be arranged in an orderly manner and all switches, fuses, and circuit-breakers shall be plainly marked, labeled, or arranged so as to afford ready means for identifying circuits or equipment supplied through them, in accordance with rule 118.

174. Spacings and Barriers against Short-Circuit

(*a*) *Bare Parts.*—Switchboards shall have the number of bare parts at different potentials on any panel reduced to a minimum, and these parts shall be effectively separated. Protection or separation of such parts by suitable barriers is recommended where the voltage exceeds 750.

It is recommended that such parts, including bus bars, should be so located, or provided with such insulating coverings or barriers, that parts at different potentials will not be readily short-circuited by tools or other conducting objects.

(*b*) *Fuses.*—Fuses should be so located as to minimize the danger, in removing or replacing them, of short-circuiting parts at different potentials by the fuses or by the hands of the operator.

175. Switchboard Grounding

(*a*) *Frames.*—Switchboard frames and noncurrent-carrying parts shall be permanently grounded under the conditions and with the exceptions noted in rule 113.

Parts of switchboards, such as name plates, screws, and similar small parts which are not liable to become alive, except under very unusual circumstances, are not considered as coming under the rule and may be left ungrounded.

(*b*) *Circuits Worked on.*—Where protective grounds are occasionally required on circuits for the protection of workmen, a permanent ground connection shall be provided, and also suitable means for effectively and readily connecting the parts being grounded to the ground connection, in accordance with rule 113 (*c*).

176. Guarding Live Parts on Switchboards

(*a*) *Inclosure.*—All switchboards operating at more than 300 volts to ground and located near passageways shall be guarded from these by suitable inclosures or barriers and shall (unless under constant attendance during operation) be made inaccessible to other than authorized persons.

(*b*) *Mats.*—For the protection of the operator, where parts of more than 300 volts to ground are not otherwise guarded or isolated by elevation, suitable insulating floors, mats, or platforms providing good footing shall be so placed that the operator can not readily touch the live parts, unless standing on such floors, mats, or platforms.

(*c*) *Parts of More than 750 Volts on Face of Board.*—No switchboard shall have exposed on its face within 6 feet from floor line any current-carrying part of more than 750 volts, except as noted in paragraph (*e*) below, and excepting direct-current railway boards not exceeding 1500 volts, which, where exceeding the nominal 750 volts, shall be so constructed that the operator can not inadvertently touch parts of more than 750 volts.

Dead-face panels and remote control are recommended as means for accomplishing this result where isolation by elevation is impracticable or undesirable.

(*d*) *Guards on Back of Board.*—When working space adjacent to live parts can not be provided in accordance with rule 114 (*a*) and (*b*), suitable guards shall be arranged to protect the operator from accidental contact with parts of more than 300 volts.

Suitable insulating guard rails, sufficiently spaced from the face or back of the board, or suitable guards perpendicular to the face or the back of the board, and extending out beyond the live parts, are recommended where practicable.

(*e*) *Plug-Type Switchboards.* — Plug-type switchboards should, except while connections are being changed, have no current-carrying part exposed on face of boards and, if practicable, they and their plug connectors shall be so arranged where the operating voltage exceeds 150 as to have all current-carrying parts guarded so long as they are alive, even while connections are being changed.

(*f*) *Instruments.*—Metal cases of instruments (unless isolated by elevation) operating at more than 750 volts should be grounded or inclosed in suitable covers of insulating material.

(*g*) *Exposed Parts of More than 7500 Volts.*—No switchboard shall have current-carrying parts of more than 7500 volts exposed (unguarded) unless these parts are effectively isolated by elevation, except at times when occasionally left exposed by removal of covers or entrance into inclosures, such as switch and instrument-transformer cells or compartments, which are ordinarily unoccupied by persons. For such parts, if exposed while alive for any purpose (including busses and disconnectors in compartments), working space shall be provided complying with the requirements under rule 114.

SEC. 18. LIGHTNING ARRESTERS

180. Location

(*a*) *Where Required.*—Lightning arresters shall be attached to all ungrounded sides of each system of more than 7500 volts connected to overhead circuits except circuits in cables with grounded metal sheath.

This rule need not be complied with in locations where thunderstorms are infrequent at all seasons of the year.

(*b*) *Indoors.*—Lightning arresters with auxiliaries, when installed inside of buildings shall be located well away from all other equipment, passageways, and combustible parts of buildings. When of a type containing oil they should be installed in accordance with rule 108.

181. Provisions for Disconnecting

(*a*) *Air-Break Disconnectors.*—Lightning arresters on circuits of more than 7500 volts shall be so arranged, isolated, and equipped that they may be readily disconnected from conductors to which they are connected by air-break manual disconnectors, having air gaps of not less than four times the equivalent needle-point sparking distance in air of the operating voltage of the circuit to which the arresters are connected, and never less than 8 inches.

(*b*) *Working Space.*—Such disconnectors, unless remotely controlled and operated, shall have the adjacent working spaces required by rule 114 (*d*) for disconnectors generally.

182. Connecting Wires

Ground wires shall be run as directly as possible and be of low impedance and ample current capacity. (See sec. 9 for methods of protective grounding.)

Kinks, coils, and sharp bends in the wires between the arresters and the outdoor lines shall be avoided as far as possible.

183. Grounding Frames and Cases of Lightning Arresters

All noncurrent-carrying metal parts of arresters shall be grounded, unless effectively isolated by elevation or guarded as required for live parts of the voltage of the circuit to which the arrester is connected, and suitably identified as of that voltage, in accordance with rule 113.

184. Guarding Live and Arcing Parts

(*a*) *Protection from Contact or Arcing.*—All current-carrying parts of arresters on circuits of more than 750 volts, unless effectively isolated by elevation, shall be adequately guarded to protect persons from inadvertent contact with them, or from injury by arcing, in accordance with rules 115 and 116.

(*b*) *Making Adjustments.*—Lightning arresters, unless provided with disconnectors which are always opened before work is done on the arresters, shall be so arranged that necessary adjustments are possible (without approach to current-carrying parts) through the use of permanently grounded mechanisms or suitable insulating appliances. Where charging or adjusting must be done with arresters alive, permanently grounded mechanisms or suitable insulating appliances shall always be provided.

(c) *Insulation of Attachments.*—All choke coils, gap electrodes, or other attachments, inherent to the lightning protective equipment, shall have an insulation from the ground or other conductors equal at least to the insulation demanded at other points of the circuit in the station.

PART 2. RULES FOR THE INSTALLATION AND MAINTENANCE OF OVERHEAD AND UNDERGROUND ELECTRICAL SUPPLY AND SIGNAL LINES

CONTENTS

SEC. 20. SCOPE OF RULES AND GENERAL REQUIREMENTS

200. Scope of Rules

(a) *Extent of Application.*—The following rules apply to electrical supply and electrical signal lines in overhead and underground construction, whether operated in connection with public utilities, privately or municipally owned, with industrial establishments, or otherwise.

(b) *Not Complete Specifications.*—These rules are not complete specifications, but are intended to embody the requirements which are most important from the standpoint of safety to employees and the public.

(c) *Conformity with Good Practice.*—Construction should be made according to accepted good practice for the given local conditions in all particulars not specified in the rules.

201. Application of the Rules and Exemptions

(a) *Intent, Modification.*—The rules shall apply to all installations except as modified or waived by the proper administrative authority. They are intended to be so modified or waived whenever they involve expense not justified by the protection secured, or for any other reasons are impracticable; or whenever equivalent or safer construction can be more readily provided in other ways.

(b) *Realization of Intent.*—The intent of the rules will be realized: (1) By applying the rules in full to all new installations, reconstructions, and extensions, except where, for special reasons, any rule is shown to be impracticable, or where the advantage of uniformity with existing construction is greater than the advantage of construction in conformity with the rules; (2) by placing guards on existing installations or otherwise bringing them into compliance with the rules, except where the expense involved is not justifiable.

The time allowed for bringing existing installations into compliance with the rules as specified in (2) will be determined by the proper administrative authority (*c*) *Waiver for Temporary Installations.*—It will sometimes be necessary to modify or waive certain rules in cases of temporary installations or installations which are soon to be discarded or reconstructed.

(*d*) *Waiver in Emergencies.*—In cases of emergency or pending decision of the administrator, the person responsible for the installation may decide as to modification or waiver of any rule, subject to review by proper authority.

202. Design and Construction; Accessibility

(*a*) *Suitable Design and Construction.*—All electrical supply and signal lines and equipment shall be of suitable design and construction for the service and conditions under which they are to be operated, and all lines shall be so installed and maintained as to reduce the life hazard as far as practicable.

(*b*) *Accessibility.*—All parts which must be examined or adjusted during operation shall be so arranged as to be readily accessible to authorized persons, by the provision of adequate clearances between conductors and of adequate climbing and working spaces and facilities.

203. Minimum Requirements

The rules state the minimum requirements for spacings, clearances, and strength of construction. More ample spacings and clearances or greater strength of construction may be provided, if other requirements are not neglected in so doing.

Some of these minimum values are exceeded in much existing construction; service requirements frequently call for stronger supports and higher factors of safety than the minimum requirements of these rules.

204. Inspection and Tests

(*a*) *Lines and Equipment.*—Electrical lines and their equipment shall comply with these safety rules when placed in service, and shall from time to time be systematically inspected by the person responsible for the installation, and when necessary, subjected to tests to determine their fitness for service. Any defects revealed by such inspection shall be recorded, if not promptly corrected. Defective lines and equipment shall be put in good order or effectively disconnected. Lines permanently abandoned, which may create a hazard, shall be removed.

Overhead service loops to consumers are often disconnected without removal when the service is discontinued This is considered good practice where it is undesirable to remove the service loop entirely.

(*b*) *Lines Out of Service.*—Lines temporarily out of service shall be maintained in such condition that a hazard will not be created. Infrequently used supply lines and equipment shall be inspected to see if they are in safe condition for service.

205. Isolation and Guarding

(*a*) *Current-Carrying Parts.*—To promote safety to the general public and to employees not authorized to approach conductors and other current-carrying parts of electrical supply lines, such parts shall be so arranged as to provide adequate clearance from the ground or other space generally accessible, or shall be provided with guards so as to effectively isolate them from accidental contact by such persons.

(*b*) *Noncurrent-Carrying Parts.*—In urban districts, ungrounded metal sheathed service cables, service conduits, metal fixtures, and similar noncurrent-carrying parts, where liable to become charged to more than 300 volts to ground (see rule 206 *b* and 213 *h*) shall be so isolated or guarded as not to be exposed to accidental contact by unauthorized persons. Metal poles not guarded or isolated shall always be specially grounded where in contact with metal sheathed cable or metal case of equipment operating at more than 750 volts.

Metal poles not guarded, isolated, or specially grounded, should always be considered as imperfectly grounded, and the insulators supporting line conductors as well as the strain insulators in attached span wires should therefore have a suitable margin of safety and be maintained with special care to prevent leakage to the pole as far as practicable.

(c) *Guards and Warning Signs.*—If supply conductors of more than 300 volts to ground are carried on poles stepped nearer than 6.5 feet from the ground or from other readily accessible space; or on closely latticed poles or towers, guards or warning signs should be used except on fenced rights of way to protect against careless approach to the conductors by unauthorized persons.

Exception: On poles carrying signal cable or twisted pairs below supply conductors, a wood block may be placed on the pole not less than 3.5 feet from the ground or other readily accessible place without necessitating the use of guards or warning signs.

206. Grounding Circuits and Equipment

(a) *Methods.*—Permanent grounding for lightning arresters, for circuits, for equipment, and for wire runways shall be done according to the rules specified in section 9, except for signal circuit arresters, for which see rule 393.

(b) *Conduit, Cable Sheaths, Hangers, etc.*—In urban districts, metal conduits, cable sheaths, frames, cases, and hangers of equipment shall be permanently grounded, except (1) when guarded from accidental contact of unauthorized persons; (2) when 8 feet or more from the ground; (3) or when metal conduit and cable sheaths (inclosing signal conductors, or supply conductors of not more than 300 volts to ground) are not exposed to probable contact with circuits of more than 300 volts to ground. (See rule 205 *b*.)

Metal conduit above ground, where containing extensions from underground metal-sheathed cable, is considered as sufficiently grounded by the sheath, if the sheath itself is in good contact with earth or is connected to a good ground. (See sec. 9.) It is recommended that supply cables have the sheath bonded to any conduit extending above the ground surface.

207. Arrangement of Switches

(*a*) *Indicating.*—All switches shall be readily accessible to authorized persons and shall indicate clearly whether open or closed.

(*b*) *Uniform Position.*—To minimize operating errors the handles or control mechanism for switches shall, as far as practicable throughout any system, have the same position when open, and a uniformly different position when closed. Where it is advisable to depart from this practice the switches should be so marked as to minimize the liability to mistakes in operation.

208. Identification of Conductors and Poles

(*a*) *Conductors.*—All conductors and equipment of electrical supply and signal lines should be arranged to occupy definite positions throughout, as far as practicable, or shall be so constructed, located, marked, or numbered as to facilitate identification by employees authorized to work thereon. This does not prohibit systematic transposition of conductors.

(*b*) *Supporting Structures.*—Poles, towers, and other supporting structures on which are maintained electrical conductors shall be so constructed, located, marked, or numbered, as to facilitate identification by employees authorized to work thereon. Date of installation of such structures shall, where practicable, be recorded by the owner.

209. Tree Trimming

Where trees exist near supply-line conductors, they shall, if practicable, be so trimmed that neither the movement of the trees nor the swinging or increased sagging of conductors in wind or ice storms or at high temperatures will bring about contact between the conductors and the trees; except that for the lower-voltage conductors, where trimming is difficult, the conductor may be protected against abrasion and against grounding through the tree by interposing between it and the tree a sufficiently nonabsorptive and substantial insulating tubing or strip.

SEC. 21. GENERAL RULES FOR POLE LINES

210. Compliance with Other Rules and Special Precautions

(a) *Other Rules.*—The rules of this section apply to all pole lines whether or not they are required by section 23 to have a definite grade of construction. The additional requirements for supply lines in those situations which are required to have a definite grade of construction, A, B, or C, will be found in sections 25, 26, and 27.

Rules 211, 212, 213, and 217 apply also to signal lines whether or not they are required by section 23 to have a definite grade of construction.

The clearances and separations of conductors, climbing space, vertical wiring on all poles, and clearances from other structures shall comply with the requirements of section 22.

(b) *Special Precautions.*—Where conductors are attached to structures other than those used solely or principally for supporting lines, all rules shall be complied with in so far as they apply, and such additional precautions as may be deemed necessary by the administrative authority shall be taken to avoid injury to such structures or to the persons using them. The supporting of conductors on trees and roofs should be avoided, where practicable.

211. Location of Poles and Towers

(a) *Clearances from Hydrants.*—Poles, towers, and other supporting structures and their guys and braces shall be so located, when practicable, as to provide horizontal clearances from them to the nearest point of hydrants and signal pedestals of not less than 4 feet, and to curb lines (unless structures are suitably protected from traffic) of not less than 6 inches.

(*b*) *Near Street Corners.*—Where hydrants are located at street corners, poles should not be set so far from the corners as to make necessary the use of flying taps inaccessible from the poles. (See rules 202 *b* and 215 *a*.)

(*c*) *Guards.*—Where necessary, poles and towers exposed by traffic to abrasion or other damage which would materially affect the strength of the support, shall be protected by guards.

(*d*) *Clearance from Rail.*—Where railway tracks are paralleled by overhead lines, the poles shall, if practicable, be located not less than 12 feet from the nearest track rail, except that at sidings a clearance not less than 7 feet may be allowed. At loading sidings sufficient space must be left for a driveway.

Supports for overhead trolley contact conductors may be located as near their own track rail as conditions require. If very close, however, permanent screens on cars will be necessary to protect passengers.

(*e*) *Rubbish.*—Poles and towers shall be so placed, guarded, and maintained as to be exposed as little as practicable to brush, grass, rubbish, or building fires.

212. Guys and Anchors

(*a*) *When Required.*—When the mechanical loads to be imposed on poles, towers, or other supporting structures are greater than can be safely supported by the poles or towers alone, additional strength shall be provided by the use of guys, braces, or other suitable construction.

(*b*) *Angles and Dead Ends.*—Guys should also, when necessary, be used wherever conductor stresses are not balanced, as at corners, angles, dead ends, and changes of grade of construction. This is to prevent undue increase of sags in adjacent spans as well as to provide sufficient strength for those supports on which the stresses are considerably unbalanced.

(*c*) *Guys Take Total Load.*—When guys are used with wood or other poles or towers capable of considerable deflection before failure they shall be able to support the entire stress in the direction in which they act, the pole acting simply as a strut. The guy should be attached to the structure as near as practicable to the center of the conductor load to be sustained.

(*d*) *Guy Fastenings.*—Guy wires should be stranded and where attached to anchor rods should be protected by suitable guy thimbles. Cedar and other softwood poles to which any guy having a strength of 10 000 pounds or more is attached, should be protected by the use of suitable guy shims, and in this case guy hooks or other suitable means should be provided to prevent the guys from slipping along the poles. Guy hooks should also be used wherever the horizontal distance from anchor to pole is less than two-thirds the vertical height of the guy attachment to the pole above the anchor.

(*e*) *Guy Insulation.*—Guys attached to metal poles or structures should be insulated from them by suitable blocking, when liable to be subject to electrolysis of the anchors, unless insulators are placed in the guys themselves.

(*f*) *Anchor Rods.*—Anchor rods shall be so installed as to be in line with the pull of the attached guy when under load, except in rock or concrete.

213. Insulators or Mechanical Guards for Guy and Span Wires

(*a*) *Where Required.*—Except as noted below, each guy wire or guy cable attached to any pole or structure carrying supply conductors of more than 300 volts to ground, and not more than 15,000 volts, or where exposed to such voltage by other lines, shall be equipped with an effective insulator located not less than 8 feet above the ground, and at such a point that if the guy wire breaks at or below the insulator, or a supply conductor falls upon it, the part above the insulator can not be reached from the ground.

(*b*) *Two Insulators.*—When the guy wire to any pole carrying supply or signal conductors, or both, is carried above or under overhead supply conductors of more than 300 volts to ground, two or more insulators shall, where hazard would otherwise exist, be used so that so far as possible the exposed section of the guy wire shall be between two insulators. Neither insulator shall be within 8 feet from the ground.

(*c*) *Grounding of Guy.*—The anchored end of the guy wires attached to wood poles carrying lines of more than 15 000 volts shall, except in rural districts, be permanently grounded (see sec. 9) wherever this part of the guy has a clearance of less than 8 feet to ground, unless an insulator is used which is permanently effective against the highest voltage which is liable to be impressed upon it.

(*d*) *Location of Insulators.*—Where guys in which it is necessary to install insulators are so arranged that one crosses or is above another, insulators shall be so placed that in case any guy sags down upon another the insulators will not become ineffective.

(*e*) *Strength.*—Guy insulators shall have a mechanical strength at least equal to that of the guys in which they are installed.

(*f*) *Exceptions.*—The placing of an insulator in a guy wire or guy cable will not be required where the guy wire or guy cable is electrically connected to grounded steel structures or to a ground connection on wooden poles.

Where guys are uniformly permanently grounded (see sec. 9) throughout any system of overhead lines, strain insulators will not be required.

(*g*) *Span Wire Insulators.*—All span wires, including bracket span wires, shall have a suitable insulator (in addition to an insulated hanger if used) inserted between each point of support of the span wire and the lamp or trolley contact conductor supported, except that single insulation may be permitted when the span wire or bracket is supported on wooden poles supporting only trolley, railway feeder, or signal conductors used in the operation of the railway concerned. This rule does not apply to insulated feeder taps used also as span wires.

(*h*) *Insulators in Suspension Ropes*.—Effective insulators should be inserted at least 8 feet from the ground in metallic suspension ropes or chains supporting lighting units of series circuits.

(*i*) *Mechanical Guards*.—The ground end of all guy wires or cables attached to ground anchors exposed to traffic shall be provided with a substantial and conspicuous wood or metal guard not less than 8 feet long.

It is recommended that in exposed or poorly lighted locations such guards be painted white or some other conspicuous color.

214. Transformers, Regulators, Lightning Arresters, Switches, and Similar Equipment on Supply Lines

(*a*) *Location on Pole*.—Transformers, regulators, lightning arresters, and switches when located below conductors or other attachments shall be mounted outside of the climbing space.

On buck-arm poles the climbing space and the lateral working spaces parallel to either the line arms or the buck arms shall be kept clear, if practicable.

(*b*) *Guarding*.—Current-carrying parts of switches, automatic circuit-breakers, and lightning arresters, if of more than 300 volts to ground, and located on the climbing side of the pole, shall be inclosed or suitably guarded, if less than 20 inches from the pole center, except when located on or above the top cross arm. The spacing between transformers and similar equipment of supply lines, and signal equipment including conductors shall not be less than is required for the spacing between supply conductors and signal conductors in similar situations. (See Table 8.)

(c) *Working Space.*—All current-carrying parts of switches, fuses, lightning arresters, also transformer connections and other connections which may require operation or adjustment while alive and are exposed at such times, shall be so arranged that in their adjustment while alive the hand need not be brought nearer to any other current-carrying part at a different voltage than the clearances from pole surfaces required in Table 5 for conductors of corresponding voltages. (See also rules 440, 441, and 442.)

215. Branch Connections

(a) *Accessibility.*—Connections of branches in supply circuits, service loops, and equipment in overhead construction shall be readily accessible to authorized employees. When possible connections shall be made at poles or other structures. (See rules 202 *b* and 211 *b*.)

(b) *Clearance.*—Such connections shall be so supported and spaced that swinging or sagging can not bring them in contact with other conductors, or interfere with the safe use of pole steps, or reduce the climbing or lateral working space. (See rules 225 and 226.)

216. Lamps

(a) *Location.*—All exposed metal parts of lamps and all such parts of their supports unless effectively insulated from the parts carrying current shall be maintained not less than 20 inches from surfaces of pole structures if of wood (unless at pole tops) and maintained at a suitable height above roadways and footways.

When lamps are maintained on the side of the pole structure opposite that designated as the climbing side this clearance may be reduced to 5 inches.

(b) *Material of Suspension.*—The lowering rope or chain for lighting units arranged to be lowered for examination or maintenance shall be of a material and strength designed to withstand climatic conditions and to safely sustain the lighting unit. The lowering rope or chain, its supports, and fastenings shall be examined periodically.

(c) *Disconnectors.*—A suitable device shall be provided by which each lighting unit on series circuits of more than 300 volts to ground may be safely and entirely disconnected from the circuit before the lamp is handled unless the lamps are always worked on from suitable insulating stools, platforms, or tower wagons, and treated as under full voltage of the circuit concerned.

Exempted from this provision are lamps, such as incandescent lamps, which in themselves present a noncurrent-carrying surface which may be utilized as a handle to safely remove them from the circuit.

217. Strength of Poles and Cross Arms

(a) *Poles.*—Poles used for lines for which no designated grade is required shall be of such initial size, and so guyed or braced where necessary as to safely withstand the loads to which they may be subjected, including linemen working on them.

(b) *Cross-arm Bracing.*—Cross arms shall be securely supported, by bracing if necessary, so as to safely support loads to which they may be subjected in use, including linemen working on them. Any cross arm or buck arm except the top one shall be capable of supporting a vertical load of 225 pounds at either extremity in addition to the weight of the conductors.

(c) *Location of Cross arms.*—In general, cross arms should be maintained at right angles to the axis of the pole and to the direction of the attached conductors, and at crossovers should be attached to that face of the structure away from the crossing, unless special bracing or double cross arms are used.

Double cross arms are generally used at crossings, unbalanced corners, and dead ends in order to permit conductor fastenings at two insulators, and so prevent slipping, although single cross arms might provide sufficient strength. To secure extra strength, double cross arms are frequently used, and cross-arm guys are sometimes used.

218. Conductors—Material and Minimum Sizes

(a) *Material.*—All supply conductors shall be of copper, aluminum (with or without steel reinforcement), copper-covered steel, or other material which will not corrode excessively under the prevailing conditions.

(b) *Minimum Sizes.*—Supply conductors in urban districts shall be not smaller than listed in the following table:

TABLE 1.—Minimum Sizes of Supply Conductors (Urban Districts)

Soft copper	No. 6 A. W. G.
Hard or medium drawn copper	No. 8 A. W. G.
Steel	No. 9 Stl. W. G.

Stranded aluminum	Spans 150 feet or less	Spans over 150 feet
Not reinforced	No. 1, A. W. G	No. 0, A. W. G.
Steel reinforced	No. 6, A. W. G	No. 4, A. W. G.

It is recommended that except as modified in Table 9, rule 246 (b), these minimum sizes for copper and steel be not used in spans longer than 150 feet for heavy-loading districts, and 175 feet for medium and light-loading districts.

Lightning-protection wires paralleling the line conductors shall be regarded, in respect to size and material requirements, as supply conductors.

219. Minimum Sizes and Sags of Service Leads

(a) *More than 750 Volts.*—Supply service leads of more than 750 volts to ground shall comply, as to sizes and sags, with the requirements for supply line conductors of the same voltage.

(b) *Not More than 750 Volts.*—Supply service leads of 750 volts or less in spans not exceeding 150 feet shall be not smaller than the sizes listed in the table below. Such leads shall have sags not less than 12 inches for spans 100 feet or less, 18 inches for spans up to 125 feet, and 27 inches for spans up to 150 feet.

TABLE 2.—Minimum Sizes of Service Leads of Not More than 750 Volts

Situation	Spans 150 feet or less
Alone Concerned with signal lines Over supply lines of less than 750 volts	No. 10 if soft copper. No. 12 if medium or hard copper. No. 12 if steel.
Over trolley of less than 750 volts Over any trolley in rural districts Over supply lines of 750 to 7,500 volts Over supply lines of more than 7,500 volts in rural districts.	No. 8 if soft copper. No. 10 if medium or hard copper. No. 12 if steel.
Over trolley of more than 750 volts in urban districts Over supply lines of more than 7,500 volts in urban districts.	No. 6 if soft copper. No. 8 if medium or hard copper. No. 9 if steel =grade C requirements.

Supply-service leads of 750 volts or less in spans exceeding 150 feet shall be not smaller than required for grade C in Table 9, rule 246, and shall have sags not less than required for grade C in the sag tables of Appendix A.

(c) *Cabled Service Leads.*—In lieu of separate conductors supply service leads may be grouped together in a cable, no individual conductor of which should be of less size than permitted for separate conductors. The sags should be the same as required above, for the individual conductors where carried separately.

SEC. 22. CLEARANCES AND SEPARATIONS OF WIRES

220. Clearances of Conductors and Wires at Crossings

(a) *Clearances above Railways,*[1] *Roadways, and Footways.*—The clear space between the lowest overhead line conductor,

[1] For wire crossings over railways handling only cars considerably lower than ordinary freight cars, the clearances of Table 3 may be reduced by an amount equal to the difference in height between the highest car handled and the highest ordinary freight car, but not less than required for street crossings.

guy, messenger, arc, or trolley span wire, or lightning-protection wires and the surfaces of rails, streets, highways, alleys, or generally accessible spaces across or along (and above) which the former pass, shall not be less than given in Table 3, at 60° F with no wind, where the conductor or wire has fixed supports and the span does not exceed 150 feet.

TABLE 3.—Clearance from Ground or Rails

[The numbers represent the clearances in feet to be provided by the conductors or wires at the heads of columns, above places specified at the side of the table.]

Nature of crossing	Clearance for the several groups—			
	For signal, guys, spans, lighting-protection wires, supply lines or services less than 300 volts to ground, messengers	For 300 volts to ground up to 15 000 volts	For 15 000 to 50 000 volts	For trolley contact wires (not feeder cables)
Crossing above track rails of railroads handling freight cars where brakemen are permitted on top	[a] 27	[a] 28	30	[b] 22
Crossing or along streets or alleys in urban districts or crossing street or roads in rural districts (over the traveled way) or over track rails not included above	[c, d] 18	20	22	[e] 16
Along roads in rural districts	[c] 15	18	20	[e] 16
Crossings above spaces or ways accessible to pedestrians only	[f] 12	15	17	[e, g] 16

[a] This clearance may be reduced to 25 feet when paralleled by trolley contact conductor on the same street or highway.

[b] In communities where 21 feet has been established, this clearance may be continued if carefully maintained. The elevation of the contact conductor should be the same in the crossing and next adjacent spans.

[c] This does not apply to guys which are not carried over, but merely beside streets or alleys, unless also over driveways. Over roadways to residence garages, 10 feet is sufficient clearance. For conductors along roads where the location of the pole relative to fences, ditches, embankments, etc., is such that the ground under the line will never be traveled except by pedestrians, the clearance above the ground may be reduced to 10 feet for signal conductors and to 12 feet for supply conductors.

(Footnotes continued on page 92.)

(*b*) *Increased Clearances.*—Greater clearances than given in Table 3 shall be provided under the following conditions:

(1) For spans longer than 150 feet the clearances shall be increased by 1 inch for each 10 feet of the excess between 150 and 300 feet and by 1 inch for each 20 feet of the excess beyond 300 feet.

(2) For voltages greater than 50 000, the clearances given shall be increased at the rate of 0.5 inch for each 1000 volts of the excess.

(3) Where the lowest supply conductor at a crossing over track rails is supported by suspension insulators the initial clearances shall be sufficient to prevent the minimum clearances over rails given in Table 3 from being reduced more than 10 per cent through the breaking of a conductor in either adjoining span.

The arrangement of insulators so that they are restrained from displacement toward the crossing will avoid the necessity of any increase over the clearances given.

(4) The above increases are cumulative when more than one applies.

(*c*) *Conductors and Wires Crossing Others.*—The clear space between the lowest overhead line conductor or wire and any other conductor or wire over which the former crosses (except for crossings between conductors and guy wires or span wires on the same poles, for which see rule 221) shall not be less than given in Table 4 at 60° F with no wind, where the upper conductor or wire has fixed supports, and the sum of the distances from the point of intersection to the nearer supporting structure of each span does not exceed 100 feet.

(Footnotes continued from page 91.)

[d] Where with guys crossing streets or alleys the section of the guy concerned is effectively insulated from the highest voltage to which it is exposed, up to 7,500 volts, this value may be decreased, in urban districts, to 16 feet at the side of the traveled way.

[e] This clearance is the minimum clear height in the middle of the trolley contact conductor span, and the point of support at the trolley hanger should be at a height not less than 18 feet above the track rail, thus allowing 2 feet for the total maximum sag at 60° F in span wire and trolley contact conductor. For trolley contact conductors of more than 750 volts to ground this clearance shall be increased by 2 feet.

[f] Signal conductors of less than 150 volts to ground need have only 10 feet clearance. Supply or other wires (except trolley contact wires) if of less than 150 volts to ground need not have more than 10 feet clearance at entrance to buildings. For guys, 8 feet will be sufficient and no clearance is required for anchor guys not passing across pathways, or for those parallel with sidewalk curbs where traffic guards are provided.

[g] Trolley contact conductors for industrial railways where not along or crossing over roadways may be placed at a less height if suitably guarded.

Conductors of lines operating at the voltages indicated at the heads of columns should, in general, be installed above those to the left of the table, where a clearance is given in boldface type. The insertion of a given clearance in italics indicates that in general the lines operating at the voltage named above this clearance should not cross over the lines at the voltage to the left of the italicized clearance.

TABLE 4.—Wire-Crossing Clearances in Feet

Wires crossing over / Wires crossed over	Signal	0 to 750 volts		Supply wires and services		Guys, messengers, span wires lightning-protection wires[a]
		Supply wires	Services	750 to 7500 volts	7500 to 50 000 volts	
Signal (including their cables and messengers)	**2**	[b] **4**	**2**	**4**	**6**	**2**
Supply, 0 to 750	*4*	**2**	**2**	**2**	**4**	**2**
750 to 7500	*4*	*2*	*4*	**2**	**4**	**4**
7500 to 50 000	*6*	*4*	*6*	*4*	**4**	**4**
Trolley-contact conductors	[c] **4**	[c,d]	**4**	**6**	**6**	**4**
Guys, messengers, span wires, lightning-protection wires, services 0 to 750	**2**	**2**	**2**	**4**	**4**	**2**

[a] Completely insulated sections of guys to supporting structures having no conductor of more than 7500 volts may have less than this clearance from each other.

[b] A clearance of 2 feet may be permitted where the supply conductor is above the signal conductor, provided the crossing is not within 6 feet from any pole concerned in the crossing, and the voltage to ground does not exceed 300 volts.

[c] Trolley-contact conductors of more than 750 volts should have at least 6 feet clearance. This clearance should also be provided over lower voltage trolley-contact conductors unless the crossover conductors are beyond reach of a trolley pole leaving the trolley-contact conductor or are suitably protected against damage from trolley poles leaving the trolley-contact conductor.

[d] Trolley feeders are exempt from this clearance requirement for trolley-contact conductors if they are at the same nominal potential and of the same system.

(*d*) *Increased Clearances.*—Greater clearances than given in Table 4 shall be provided under the following conditions:

(1) Where the sum of the distances from the nearest supporting structures of the two spans concerned to their point of intersection exceeds 100 feet, the clearances shall be increased by 2 inches for each 10 feet of the excess between 100 and 200 feet and by 2 inches for each 20 feet of the excess beyond 200 feet.

(2) For voltages greater than 50 000 the clearances shall be increased at the rate of 0.5 inch for each 1000 volts of the excess.

(3) Where the upper line at a crossing between two lines is supported by suspension insulators, the clearances above lines crossed shall be increased sufficiently above those given in Table 4 to prevent the clearances from being reduced by the breaking of a conductor in either adjoining span by more than 25 per cent below the value given in Table 4.

The arrangement of insulators so that they are restrained from displacement toward the crossing will avoid the necessity of any increase over the clearances given.

(4) The above increases are cumulative when more than one applies.

221. Minimum Values of Line-Conductor Clearances and Horizontal Separations at the Supports

(*a*) *Clearances and Separations.*—At any fixed support the clearances of line conductors from their supporting structures and attachments thereto (except insulators to which any conductor is attached), and the horizontal separation between any two line conductors, shall be not less than the values given in the following table. The requirements of rule 222 apply if they give a greater separation than this rule.

Cables, duplex, triplex, and twisted-pair conductors, supported on insulators or messengers, whether single or grouped, are considered single conductors, even though they may contain individual conductors not of the same phase or polarity. Clearances between individual wires or cables supported by the same messenger or between any group and its supporting messenger are not subject to the provisions of this rule.

The clearances and separations stated may be measured from the center of the supporting insulator instead of from the conductor itself.

TABLE 5.—Minimum Line-Conductor Clearances and Separations at Supports

[Applying to conductors of the same circuit or of different circuits. (See also rule 223 for lateral working space.)]

Classification concerned	Horizontal separation between conductors not of the same phase or polarity	Clearance from span and guy wires attached to the same pole or from vertical or lateral conductors of other circuits	Clearance from surfaces of poles or cross arms or from vertical or lateral conductors of the same circuit
	Inches	Inches	Inches
Signal	(a)	3	[b]3
Direct-current railway feeders No. 4/0 or larger, 0–750 volts	6	[e]6	3
Railway feeders 750–7500 volts and direct-current railway below No. 4/0, 0–750 volts	[d]12	[c, e]6	3
Supply conductors 0–7500 volts	[f, d]12	[c, e]6	3
For all conductors of more than 7500 volts add, for each kilovolt in excess of 7500 volts	0.4	[e]0.4	0.25

[a] The preferable minimum separation is 6 inches, but where cross arms having less pin spacings than this have been in regular use, a separation of 3 inches will be permitted. This requirement does not apply at points of transposition of signal-line conductors.

[b] Signal conductors may be attached to supports on the sides or bottoms of cross arms or on the surfaces of poles, if at least 4 feet from any supply line of less than 7500 volts and at least 6 feet from any supply lines of more than 7500 volts carried on the same pole.

[c] Where a trolley feeder, supply line, or signal line is supported by the span wire concerned this clearance is not required.

[d] Where a separation of 10 to 12 inches has already been established by practice, for spans having apparent sags not over 3 feet (see Appendix A for apparent sags in level spans under different loading conditions and in different grades of construction) and for conductor voltage not more than 7500, that minimum separation may be continued, subject to the provisions of rule 222.

[e] Clearances from these conductors to guy, span, messenger, or lightning-protection wires run in the direction of the line, shall be not less than the separation required between two line conductors of the voltage concerned.

[f] Where conductors of less than 750 volts all of one material are supported on vertical racks in spans averaging not to exceed 150 feet, the minimum of 12 inches (see rule 223 g) may be reduced to one-third of this value and applied for vertical clearance.

(*b*) *Location of Wires.*—Supply lines of any one voltage classification may be maintained on the same cross arm with supply lines of the next consecutive classification under the following conditions:

(1) If they occupy pin positions on opposite sides of the pole.

(2) If in bridge-arm or side-arm construction they are separated by a distance of not less than the climbing space required for the higher voltage concerned and provided for in rule 225.

(3) If the higher-voltage conductors occupy the outer pin positions and the lower-voltage conductors the inner pin positions.

(4) If series lighting or similar circuits which are ordinarily dead during periods of work on or above the cross arm concerned occupy the inner pin position and the lower-voltage conductors occupy the outer pin position.

(5) If the two lines concerned are signal lines used in the operation of supply lines and supply lines of less than 7500 volts and are owned by the same utility provided they are installed as in (1) or (2) above.

222. Required Line-Conductor Clearances and Separations at the Supports

(*a*) *Line-Conductor Separations According to the Sags Concerned.*—The separation, at the supports, of the conductors of the same or different circuits of grades A, B, or C shall in no case be less than the values given by the following formulas, at 60° F without wind. The requirements of rule 221 apply if they give a greater separation than this rule.

For line conductors smaller than No. 2 A. W. G.:

$$\text{Separation} = 0.2 \text{ inch per kilovolt} + 6\sqrt{\frac{S}{3} - 8}.$$

For line conductors of size No. 2 or larger:

$$\text{Separation} = 0.2 \text{ inch per kilovolt} + 7\sqrt{\frac{S}{12}},$$

where S is the apparent sag in *inches* of the conductor having the greater sag, and the separation is in inches.

TABLE 6.—Separation in Inches Required for Line Conductors Smaller than No. 2 A. W. G.[a]

Voltages	Separation for sags shown						
	36	48	72	96	120	180	240
750	12.0	17.0	24.0	29	34	43	51
2 200	12.5	17.5	24.5	30	35	44	52
6 600	13.5	18.5	25.5	31	36	45	53
22 000		21.5	28.5	34	39	48	55
44 000			33.0	38	43	53	60
66 000			37.0	43	47	57	64

[a] The blank spaces indicate that for these sags and voltages the values obtained by Table 5 are greater than those obtained by the formulas of rule 222(a) and therefore apply.

TABLE 7.—Separation in Inches Required for Line Conductors of Size No. 2 A. W. G. or Larger [a]

Voltage	Sag in inches						
	36	48	72	96	120	180	240
750	12	14	17	20	22	27	31
2 200	12.5	14.5	17.5	21	23	28	32
6 600	13.5	15.5	18.5	21	24	29	33
22 000		18.5	21.5	24	27	32	36
44 000				29	31	36	40
66 000					36	41	45

[a] The blank spaces indicate that for these sags and voltages the values obtained by Table 5 are greater than those obtained by the formulas of rule 222 (a) and therefore apply.

(b) *Increased Line-Conductor Separations and Clearances at the Supports if Suspension Insulators Are Used.*—Where suspension insulators are used and are not restrained from movement, the values of conductor separation required by

Table 8 or by (*a*) above shall be increased by one-half the length of the suspension insulator string.

Where suspension insulators are used and are not restrained from movement, the conductor clearances from surfaces of supports, from span or guy wires, or from vertical or lateral conductors shall be such that the values of clearances required by Table 5 will be maintained with an insulator swing of 45° from the vertical position.

223. Minimum Lateral Working Space and Vertical Separation Between Conductors at Different Levels

(*a*) *Height of Working Space.*—The lateral working space between supply conductors and between supply and signal conductors, at different levels, shall have an approximate vertical height of not less than that given in Table 8 with a minimum of 2 feet.

(*b*) *Width of Working Space.*—This space on the climbing side of the pole extends laterally from each side of the climbing space to the outer pin position of the arm and with a minimum horizontal width from the face of the cross arm equal to the width of the climbing space required for the highest voltage conductors concerned. (See rule 225 *a*.)

(*c*) *Freedom from Obstructions.*—No vertical or lateral conductors shall obstruct this working space. Such conductors, if not on the opposite side of the pole from the climbing side, must be at least as far from the cross arms as the width of the climbing space required for the highest voltage conductors concerned.

(*d*) *Only One Buck Arm.*—Since buck arms obstruct the lateral working space between line conductors, not more than one single or double buck arm shall be placed on any pole, unless the voltage of all conductors concerned on the buck arms and adjacent line cross arms above and below does not exceed 750, or unless the lateral working space required by Table 8 is provided between the conductors attached to the buck arm and the conductors on the adjacent line arm to which the conductors on the buck arm are not connected.

This may be accomplished by increasing the spacing between the line cross-arm gains.

(*e*) *Minimum Vertical Separations between Conductors on the Same Structures but on Different Cross Arms.*—The vertical separations between conductors of the same or different voltage classifications when carried on the same structure but on different cross arms shall be not less than values given in Table 8 on page 106.

In general, conductors of lines operating at the voltages indicated at the heads of columns are to be installed at levels above those at lower voltages to the left of the table when carried on the same structures, with the exceptions in (*f*), (*g*), and (*h*) of this rule and in rules 221 (*b*), 254 (*b*), and 273 (*d*). Trolley-contact conductors and their associated feeders, which for convenience are carried at approximately the same level, are to be installed at levels below signal lines, at least 4 feet below signal lines for public use and at least 2 feet below signal lines used in operation of supply lines. (For grades of construction of the higher lines see sec. 23.)

(*f*) *Vertical Arrangement of Conductors.*—Supply conductors of the same circuit arranged vertically on separate cross arms may occupy the same cross arms with supply conductors of the next consecutive voltage classification (see Table 8) similarly arranged, provided the clearance (rule 221) and climbing space (rule 225) specified for the higher voltage are maintained at each level concerned. When so arranged, the minimum vertical separation between cross arms shall be that required in Table 8 for the highest voltage concerned.

(*g*) *Vertical Racks.*—Conductors of circuits of less than 750 volts may be carried on vertical racks at one side of the pole where normal spans do not exceed 150 feet if the full width of climbing space is maintained past the rack and at least 4 feet above and below. (See Table 5, rule 221, for necessary clearance from surface of poles.)

TABLE 8.—Minimum Vertical Separations, in Feet, between Line Conductors of the Same or Different Voltage Classification When Carried on the Same Structures but on Different Cross Arms [a]

Conductors at lower levels	Supply conductors at higher levels: 0 to 750 volts	750 to 7500 volts [b]	7500 to 15 000 volts [b]	15 000 to 50 000 volts: Different utilities	15 000 to 50 000 volts: Same utility
Signal lines	[d] 4	4	6	6	....
Signal lines used in the operation of supply lines	2	[c] 2	4	6	4
0 to 750	2	2	4	6	4
750 to 7500	....	2	4	6	4
7500 to 15 000	....	....	2	4	4

[a] The specified clearances usually indicate the minimum vertical separation between parallel cross arms (center to center) at the pole, and where these clearances are provided between the centers of the cross arms, the clearance of the conductors supported thereon may be reduced below those given in the table by an amount not to exceed 8 inches where tabular clearance is 2 feet or 4 feet, and by an amount not to exceed 12 inches where the tabular clearance is 6 feet.

[b] Where conductors are operated by different utilities a minimum vertical spacing between the respective conductor levels of 4 feet is recommended.

[c] This shall be increased to 4 feet when the signal conductors are carried above supply conductors unless the signal line conductor size is that required for grade C supply lines.

[d] In localities where the practice has been established of placing on jointly used poles, cross arms carrying supply circuits of less than 300 volts to ground and cross arms carrying signal circuits, at a vertical separation less than specified in the table, such existing construction (provided the minimum separation between the cross arms in question is not less than 2 feet) may be continued until the said poles are replaced; provided, however, that extensions to the existing construction shall conform to the clearance requirements specified in the table.

When signal lines are all in cable, a supply cross arm carrying only wires of not more than 300 volts to ground may be placed at not less than 2 feet above the point of attachment of the cable to the pole; provided that the nearest supply wire on such cross arm shall be at least 30 inches horizontally from the center of the pole, and that the cable be placed so as not otherwise to obstruct the climbing space. (See rule 225 *e*.)

(*h*) *Lines Not Worked on When Alive.*—The provisions of this rule do not apply to the vertical spacings between lines at different levels where men are not permitted to enter the spaces while the lines are alive.

224. Conductors of Different Sags on the Same Supports

(*a*) *Variation in Clearance.*—Line conductors supported at different levels on the same structure and strung to different sags shall have vertical spacings at the supporting structures so adjusted that the minimum spacing at any point in the span, at 60° F with no wind, shall not be reduced more than 25 per cent from that provided for, by rules 221, 222, and 223, at the supports.

(*b*) *Readjustment of Sags.*—Sags should be readjusted when necessary to accomplish the foregoing but not reduced sufficiently to conflict with the requirements of rule 246.

In cases where conductors of different sizes are strung to the same sag for the sake of appearance or to maintain unreduced clearances throughout storms, the chosen sag should be such as will keep the smallest conductor involved in compliance with the sag requirements of rule 246.

225. Climbing Space

(*a*) *Supply Lines Alone or on Joint Poles with Signal Lines.*—All poles or structures carrying cross arms supporting supply lines alone or supply and signal lines on joint poles shall be arranged and maintained (except as noted in (*c*) below) so as to provide an unobstructed vertical climbing space as follows:

The climbing space shall have the dimension specified horizontally each way. The climbing space need be on one side or corner only of the pole structure.

Where double cross arms are not used on any one pole and all cross arms are parallel, it is recommended that the cross arms be on the same side of the pole.

(1) With supply conductors alone of less than 300 volts to ground, the climbing space shall be not less than 24 inches.

(2) With supply conductors alone of more than 300 volts to ground, the climbing space shall be not less than 30 inches.

(3) With signal conductors below supply conductors the climbing space through the signal conductors shall be the same as the supply conductors immediately above.

(4) With signal conductors above supply conductors the climbing space through the supply conductors shall be that specified in (1) or (2), and extend 4 feet above the highest supply conductor if voltage of same is less than 7500 volts, or 6 feet if voltage is more than 7500 volts.

(*b*) *Signal Lines Alone.*—It is recommended that poles carrying only signal conductors, when these are of more than 150 volts to ground, be provided with a climbing space at least 24 inches horizontally each way.

(*c*) *Exceptions to Climbing Space Specified in* (*a*) *Above.*—When lines of voltages between 7500 and 15000 volts are worked on or climbed through when alive, a climbing space of at least 36 inches should be provided when practicable.

With lines of voltages of more than 15000 volts the proper dimensions of the climbing space will depend on the particular conditions.

The values given in (*a*) above do not apply if the unvarying practice of the employers concerned prohibit employees from ascending beyond the conductors of the given line unless the lines are killed or protected by suitable shields. If the conductors operate at less than 15 000 volts a 24-inch climbing space is permissible.

(*d*) *Protected Vertical Conductors.*—Vertical runs incased in suitable conduit or other protective covering (see rule 226) and securely attached to the surface of the pole or structure, or the pole or structure itself when included in one side or corner of this space at buck or reverse-arm construction, are not considered to obstruct the climbing space.

(*e*) *Protected Longitudinal Runs.*—Longitudinal runs of cable or conductors are not considered to obstruct the climbing space if no supply line conductors carried on cross arms are within 4 feet, either above or below (see also exception in certain cases under note [d], Table 8). But such cables or conductors must be protected where within 20 inches from pole center by suitable guard arms securely fastened to the pole, or by substantial insulating conduit, unless located above supply line conductors or at least 6 feet below. If grounded metal-sheathed cables are uninsulated from metal supports attached to wood poles, similar protection shall be provided for such supports for at least 24 inches from the pole center.

(*f*) *Special Clearance for Longitudinal Runs.*—In cases where longitudinal runs of supply conductors of not more than 750 volts are supported near the surface of the pole, as by brackets or racks, or on pins close to the pole, unless they are located at levels at least 4 feet above or below other supply conductors carried on cross arms, sufficient side clearance from the pole center shall be provided for the line conductors on the adjacent cross arms to afford the full width climbing space for at least 4 feet above and below the longitudinal run concerned.

(*g*) *Obstructions.*—All poles should be kept free from posters, bills, tacks, nails, and other unnecessary obstructions, such as through bolts not properly trimmed.

226. Clearances of Vertical and Lateral Conductors

(*a*) *Climbing and Working Spaces.*—Vertical and lateral conductors, ground wires, and metal sheathed cables shall not obstruct the vertical climbing space (for exception see rule 225), or the lateral working space between line conductors at different levels (see rule 223) or interfere with the safe use of pole steps, where such are installed.

(*b*) *Clearances between Conductors and from Conductors to Surfaces of Structures.*—Vertical and lateral conductors shall have the minimum separation and clearances from other conductors, conduits, pole surfaces, and guy, span, or messenger wires given in paragraphs (1), (2), and (3) below, excepting where installed as in (*c*), (*d*), and (*e*) below, and excepting that the provisions of these rules are not intended to prohibit the placing of supply circuits of the same or next voltage classification in the same iron pipe if each circuit or set of wires be inclosed in a metal sheath.

(1) From surfaces of supports and from other conductors of the same circuit . . . 3 inches+0.25 inch per kilovolt (highest voltage concerned), in excess of 7500 volts.

Exception under note b, Table 5, rule 221 (a), applies.

(2) From span, guy, or messenger wires and from conductors of other circuits . . . 6 inches +0.4 inch per kilovolt (highest voltage concerned), in excess of 7500 volts for supply conductors and 3 inches for signal conductors.

(3) From conductors on other supports as provided in rule 227.

The foregoing minimums are for situations where all conductors are rigidly supported on fixed supports. Where not so supported, greater separations and clearances shall be used. (See rule 222 b.)

(c) *Vertical Supply Conductors through Signal Conductors.*—Such conductors shall be installed as follows, except as provided in (e) below:

(1) *General—All Voltages.*—Vertical conductors, including ground wires which are carried through a space occupied by signal circuits, shall be inclosed in insulating conduit or in metal conduit or cable protected by an insulated covering or wooden molding except as noted in (2) below. The inclosure shall extend from a point at least 6 feet below the lowest signal conductor to a point at least 6 feet above highest signal conductor or equipment if the supply voltage is in excess of 7500 volts or to a point at least 4 feet above the highest signal conductor or equipment, if the supply voltage is less than 7500 volts.

In the latter case the clearance may be reduced to 2 feet if the supply voltage is less than 300 volts and 2 feet has been established as the vertical clearance. (See Table 8, note d.)

(2) *Exception.*—Vertical and lateral conductors of street lighting circuits and service leads of less than 750 volts may be run on the street side of the pole in multiple-conductor cable having suitable substantial insulating covering if such cable is held taut on standard insulators supported on pins or brackets and so arranged that the cable shall be held at a distance of approximately 5 inches away from the surface of the pole or from any pole steps.

(d) *Vertical Conductors through Supply Conductors.*—Conductors which are carried through supply conductors shall be installed as follows except as noted in (e) below:

(1) Vertical conductors of not more than 7500 volts shall clear pole centers by not less than 15 inches for a distance of not less than 4 feet

above and below any open supply-line conductors which are not of more than 7500 volts when the latter are carried on or within 4 feet from the pole. If the vertical conductors are of more than 7500 volts this clearance shall be at least 20 inches. If the supply conductors are of more than 7500 volts, the clearance from the pole center shall apply for a distance of not less than 6 feet above and below, except as noted in (2), (3), and (4) below.

(2) Vertical and lateral supply conductors, including ground wires which are inclosed in insulated conduit or in metal conduit or cable protected by an insulating covering (or wooden molding, if wire be used having triple-braid weatherproof insulation) whenever within 4 feet from open supply lines of less than 7500 volts or within 6 feet from open supply lines of more than 7500 may have less than the clearances specified in (1) above, except that—

(3) Vertical and lateral conductors in metal-sheathed cables and ground wires when installed on poles used only for supply lines and employing side-arm construction where the lines are carried on one side of the pole may have the insulating conduit or covering which is specified in (2) omitted.

(4) Vertical and lateral conductors of less than 7500 volts when on poles used only for supply lines may be run on the street side of the pole in multiple-conductor cable having suitable substantial insulating covering, if such cable is held taut on standard insulators supported on pins and brackets and so arranged that the cable shall be held at a distance of approximately 5 inches from the surface of the pole or any pole step.

(5) Vertical and lateral signal conductors may be attached directly to the pole by means of rings, knobs, or brackets, provided they are rubber-insulated twisted-pairs and do not come within 4 feet from open supply lines of less than 7500 volts or within 6 feet from open supply lines of more than 7500 volts. Where within such distance they shall be incased in insulating conduit or in other substantial insulating and protective covering.

(*e*) *Mechanical Protection Near Ground.*—Where within 8 feet of the ground a suitable mechanical protective covering shall be provided over all vertical conductors, including lead-sheathed cables, except that the covering may be omitted for cables and for ground wires having triple-braid weatherproof insulation in rural districts and for cables armored or installed in grounded metal conduit in urban districts. The protective covering specified above shall be of wood molding or other insulating material if for the ground wire of a lightning arrester.

(*f*) *Conductors Not in Conduit.*—Conductors not incased in conduits shall have the same clearances from conduits as from other surfaces of structures.

(*g*) *Where No Work Is Done on Live Lines.*—The provisions of (*a*) and (*d*) do not apply to portions of a pole which workmen do not ascend while the conductors in question are alive.

227. Clearances of Conductors of One Line from Poles and Conductors of Another Line

(*a*) *Clearances from Poles.*—Where conductors of one line are carried within 6 feet from a supporting structure of a second line, and are not attached thereto, the clearance between the conductors of the first line and any part of the supporting structure of the second line shall, if practicable, be not less than 3 feet at 60° F and no wind. In no case should this clearance be less than the values required by rules 221 and 222 for separation between similar conductors on the same support, increased by 1 inch for each 2 feet of the distance from the supporting structure of the second line to the nearest supporting structure of the first line. The climbing space on the structure of the second line shall in no case be reduced by a conductor of the first line.

(*b*) *Clearances from Conductors.*—The clearance in any direction, at 60° F and no wind, of any conductor of one line from any conductor of a second and conflicting line shall not be less than required by rules 221 and 222 for separation between conductors on the same support, and shall not be less than 4 feet. It shall be at least equal to the apparent sag of the conductor having the greater sag, plus 0.2 inch per kilovolt of the highest voltage concerned.

228. Clearances from Buildings

(*a*) *General.*—Conductors should be so arranged and maintained as to hamper and endanger firemen as little as possible in the performace of their duties.

(*b*) *Ladder Space.*—Where buildings exceed three stories, or 50 feet, in height, overhead lines should be arranged where practicable so that a clear space (or zone) at least 6 feet wide will be left, either adjacent to the building or beginning not over 8 feet from the building, to facilitate the raising of ladders when necessary for fire fighting.

(*c*) *Clearances (Lines of 300 to 7500 Volts).*—Supply conductors of voltages between 300 and 7500 (unless in grounded conduit or metal-sheathed cable or otherwise adequately guarded or rendered inaccessible) shall be so arranged that they do not come nearer than 3 feet, measured horizontally, from any point on the surface of a building or its attachments or nearer than 8 feet above the top of any building or above any balcony or other platform crossed over.

(1) *Guards.*—Where the above clearances can not be provided, or where supply conductors are placed near enough to windows, verandas, fire escapes, or other ordinarily accessible places to be exposed to contact of persons, the conductors shall be properly guarded by conduit, barriers, or otherwise.

(2) *Where Attached to Buildings.*—Where the permanent attachment of open supply conductors of any class to buildings is necessary for an entrance, conductors shall not be carried along or near the surface of the building unless they are guarded or made inaccessible where of more than 300 volts to ground, and shall have separations from each other and clearances from building surfaces not less than those required by Table 5 (and its notes) for separation of conductors and clearances from pole surface.

(*d*) *Clearances (Lines of more than 7500 Volts.)*—Conductors operating at more than 7500 volts (unless in grounded conduit or metal-sheathed cable or otherwise adequately guarded or rendered inaccessible) shall be so arranged that they clear the surfaces of roofs or buildings or their attachments by not less than 8 feet up to 15 000 volts and 10 feet for higher voltages.

They should not be carried over buildings not concerned in the operation of the utility owning them where this can be avoided.

229. Clearances from Bridges

(*a*) *Accessible Portions.*—Supply conductors (unless in grounded conduit or metal-sheathed cable) shall be so arranged that they do not come within 3 feet from any readily accessible wing wall or other readily accessible portion of any bridge or its attachments. For voltages higher than 7500 volts the minimum clearance shall be not less than required by paragraph (*b*) or (*c*).

(*b*) *Ordinarily Inaccessible Portions; Where Attached.*—Open supply conductors passing under, over, or near a bridge (other than brick, concrete, or masonry, requiring infrequent inspection or repair), when attached thereto, shall, when practicable, be so arranged that they do not come within the following distances from any portion of the bridge or abutments:

Operating voltage:	Clearance in feet
0 to 2 500	0.5
2 500 to 5 000	1.0
5 000 to 7 500	3.0
7 500 to 15 000	5.0
15 000 to 50 000	7.5

(*c*) *Ordinarily Inaccessible Portions; Where Not Attached.*—Open supply conductors passing over, under, or near a bridge (other than brick, concrete, or masonry, requiring infrequent inspection or repair), and not attached thereto shall be so arranged that they do not come within the following distances from any portion of the bridge or abutments:

Operating voltage:	Clearance in feet
0 to 7 500	3.0
7 500 to 15 000	5.0
15 000 to 25 000	7.5
25 000 to 35 000	9.0
Exceeding 35 000	12.0

The clearances as given above are minimums and should be increased as much as practicable.

(*d*) *Separations.*—Where supply conductors attached to bridges are supported at frequent intervals, their separation may be less than that specified in rules 221 and 222, but not less than that required by rule 221 for clearances from surfaces of poles and cross arms, or less than the following:

Span length:	Separation in inches
Up to 20 feet	6
20 to 50 feet	9

(*e*) *Trolley Contact Conductors.*—Trolley contact conductors attached to the under surfaces of bridges shall be provided with a substantial inverted trough of nonconducting material, or other suitable means shall be taken to keep the trolley pole from making connection between the trolley contact conductor and the bridge structure.

(*f*) *Warning Signs.*—The pin-supporting structure attached to bridges shall be plainly marked with the name, initials, or trade-mark of the utility responsible for the attachment, and, in addition, when the voltage of the conductors exceeds 750 volts, by the following or equivalent sign—"Danger—Do Not Touch."

SEC. 23. CLASSIFICATION OF CIRCUITS ACCORDING TO THE GRADE OF CONSTRUCTION REQUIRED

230. Required Grades of Overhead Line Construction, and Arrangement of Levels

(*a*) *Various Conditions of Hazard.*—Supply and signal lines[3] shall have mechanical construction of the grade designated as A, B, C, D, or E, depending upon the hazards involved, under the following conditions:

(1) When concerned in crossings or conflicts.
(2) Where carried on the same supports with other lines.
(3) In some cases where carried through urban districts.

[3] The rules referring to signal lines apply to all signal lines except those used in the operation of supply lines, and their application to these is determined by one of the construction methods applied to the signal lines and to neighboring lines as given in rule 289.

The conditions determining each grade of construction are defined in the following rules of this section.

Where none of these conditions exist, no specified grade of mechanical construction is required, but the general requirements given in sections 20, 21, and 22 must be met.

Grades of construction A, B, and C are described in the rules of section 24. Grades of construction D and E are described in section 28. In any case where two or more of the conditions listed below exist, the grade of construction shall be the highest called for under any item applying.

Where one line crosses over another the grade of the upper line shall not be less than the grade required for the lower line.

(*b*) *Double Crossing.*—Where a line crosses in one span over two other lines, the strength of construction shall be not less than would be required if either of the two lower lines crossed the other.

For example, if a 2300-volt line crosses in the same span over a signal line and a direct-current trolley line of more than 750 volts, the 2300-volt line would be required to comply with grade A construction at the crossing. This is a double crossing and introduces a greater hazard than where the upper supply line crosses the signal line only.

(*c*) *Arrangement of Relative Levels.*—Where supply and signal lines or supply lines of different voltage classification cross each other or are in conflict, or are on the same poles or towers, the highest voltage lines shall preferably be carried at the higher levels.

It is recommended that, where practicable, lines be arranged, by mutual agreement of the utilities concerned, at standardized levels throughout a given community, in order to minimize difficulties when new crossings or extensions to existing lines are to be installed. (See also 220 *c*, second paragraph, for relative levels.)

Where circuits of different classification are concerned in a crossing, conflict, or common use of poles, the construction for the circuit at the higher level shall be at least as good as would be required for the circuit at lower level if it were above the other.

(*d*) *Avoidance of Conflict.*—Two parallel pole lines, either of which carries supply conductors, shall, where practicable, be so separated from each other that neither conflicts with the other.

If this is impracticable, then the conflicting line or lines shall be built of the grade of construction required by the rules for a conflicting line or the two lines shall be combined in a single pole line. (See rule 234.)

231. Supply Lines in Urban Districts

(*a*) *Grade B.*—The following supply lines in urban districts shall comply with the requirements of grade B, except as given in (*b*) and (*c*) below:

(1) Lines of more than 7500 volts.

(2) Lines of any voltage carried above lines of more than 7500 volts.

(*b*) *Grade C.*—The following supply lines in urban districts shall comply with the requirements of grade C, except as given in (*c*) below:

(1) Lines of more than 7500 volts if in cable having permanently grounded continuous metal sheath or armor and complying with the requirements of rule 274.

(2) Lines of voltages between 750 and 7500.

(3) Lines of less than 750 volts when carried above lines of voltages between 750 and 7500.

(*c*) *Exceptions.*—The following supply lines in urban districts need comply only with the general requirements of sections 20, 21, and 22.

(1) Lines of voltages between 750 and 7500 if in cable having permamanently grounded continuous metal sheath or armor and installed in compliance with the requirements of rule 274 (*c*), (*d*), (*e*), (*f*).

(2) Supply lines of less than 750 volts where alone or concerned only with signal lines or with supply lines of less than 750 volts or both.

(3) Lines on fenced rights of way, except where crossing over, conflicting with or higher on joint poles with the conductors of other lines.

(*d*) *Constant-Current Circuits.*—Constant-current circuits shall meet the requirements for circuits of their nominal full-load voltage.

232. Supply Lines in Rural Districts (See Rule 252)

(*a*) *Grade C.*—When either of two supply lines in rural districts, one of more than 7500 and the other of less than 750 volts, crosses, conflicts with, or has common poles with the other, the upper one shall comply with the requirements of grade C, unless the line of higher voltage is in cable having permanently grounded continuous metal sheath or armor and is installed in compliance with rules 274 (*c*), (*d*), (*e*), (*f*).

(*b*) *Service Crossings.*—Supply lines of more than 7500 volts are exempted from this requirement if crossing over or conflicting only with service connections from supply lines.

Constant-current circuits are included in (*a*) and (*b*) above, the voltage being the nominal full-load voltage.

(*c*) *No Grade.*—Supply lines of more than 7500 volts in rural districts, where alone, or where concerned only with supply lines of more than 750 volts, need comply only with the general requirements of sections 20, 21, and 22.

Supply lines of less than 7500 volts in rural districts, except as covered in (*a*) above, need comply only with the general requirements of sections 20, 21, and 22.

233. Supply Lines Crossing Over Railways (See Sec. 26)

(*a*) *Grade A.*—Supply lines carried over railways, operated by steam, electric, or other motive power, except as provided in (*b*) and (*c*) below, shall comply with the construction requirements of grade A.

(*b*) *Grade B.*—Supply lines carried over minor tracks included in the following list shall comply with the requirements of grade B.

(1) Spurs less than 2000 feet long and not exceeding two tracks in the same span.

(2) Branches on which no regular schedule of operation is maintained.

(3) Narrow-gage tracks or other tracks on which standard rolling stock can not, for physical reasons, be operated.

(4) Tracks used only temporarily for a period not exceeding one year.

(5) Tracks not operated as a public utility, such as industrial railways used in logging, mining, etc.

(c) *Street Railway Crossings.*—Supply lines crossing over street railways on traveled portions of highways need conform only to general requirements, but when carried over trolley contact conductors shall have the same grade of construction as where crossing over supply lines of equal voltage (see rules 231 and 232).

234. Supply Lines in Crossings, Conflicts, and Joint Use of Poles with Signal Lines[3]

(a) *Grade A.*—Supply lines and signal lines under the conditions specified below shall comply with the requirements of grade A.

(1) Constant-potential alternating-current supply lines of more than 7500 volts between conductors (or 4400 volts to neutral or ground) or constant-current circuits of more than 10 amperes or direct-current trolley circuits of more than 750 volts to ground where at higher levels and crossing over, conflicting with or having joint poles with signal lines except as noted in (*b*-3) below for certain signal conductors.

(2) Signal lines carried at higher levels than the supply lines specified in (1) in crossings, conflicts, or joint use of poles.

(b) *Grade B.*—Supply lines and signal lines under the conditions specified below shall comply with the requirements of grade B.

(1) Constant-potential alternating-current supply lines of voltages between 5000 and 7500 between conductors (or between 2900 and 4400 to neutral or ground), or constant-current circuits of between 7.5 and 10

---

[3] It is not intended that the requirements of rules 234 (*a*-1,) (*b*-1,) or (*c*-1) shall apply where the signal lines concerned are individual twisted-pair drop lines only.

amperes, where at higher levels and crossing over, conflicting with or having joint poles with signal lines except as noted in (*c*–3) below for certain signal conductors.

(2) Signal lines carried at higher levels than the supply lines specified in (1) in crossings, conflicts, or joint use of poles.

(3) Supply lines specified in (*a*–1) above when at higher levels and crossing over, conflicting with or having joint poles with signal lines carrying not more than four wires used mainly for local exchange service, or only subscribers' loops, or not more than two local telegraph or fire-alarm wires.

(*c*) *Grade C.*—Supply lines and signal lines under the conditions specified below shall comply with the requirements of grade C.

(1) Constant-potential alternating-current supply lines of voltages between 750 and 5000 between conductors (or voltages between 440 and 2900 to neutral or ground) and constant-current circuits of not more than 7.5 amperes, and supply lines of more than 5000 volts in cable having permanently grounded continuous metal sheath or armor (and installed in compliance with rule 274) where at higher levels and crossing over, conflicting with, or having joint poles with signal lines.

(2) Signal lines carried at higher levels than the supply lines specified in (1), except as smaller conductor sizes are permitted by rule 283 (*d*).

(3) Supply lines specified in (*b*–1) above when at higher levels and crossing over, conflicting with, or having joint poles with signal lines carrying not more than four wires used mainly for local exchange service or only subscribers' loops, or not more than two local telegraph or fire-alarm wires.

(4) Signal lines carried over trolley contact conductors of less than 750 volts shall comply with grade C requirements as to conductor sizes and sags except as noted in rule 286.

235. Signal Lines Crossing Over Railways (See Sec. 28)

(*a*) *Grade D.*—Telephone, telegraph, and other signal lines carried over railways operated by steam, electric, or other motive power shall, with the exceptions noted below in paragraphs (*b*), (*c*), (*d*), (*e*), of this rule, comply with the construction requirements of grade D.

(*b*) *Grade E.*—Signal lines carried over minor tracks included in the following list shall conform to the requirements of grade E:

(1) Spurs less than 2,000 feet long and not exceeding two tracks in the same span.

(2) Branches on which no regular schedule of operation is maintained.

(3) Narrow-gage tracks or other tracks on which standard rolling stock can not, for physical reasons, be operated.

(4) Tracks used only temporarily for construction or similar purposes for a period not exceeding one year.

(5) Tracks not operated as a public utility, such as industrial railways used in logging, mining, etc.

(*c*) *Street Railways.*—Signal lines carried over street railways not having overhead trolley contact conductors need comply only with the general requirements for signal lines alone. (See rule 288 and secs. 21 and 22.)

(*d*) *Trolleys.*—Where signal lines cross over trolley contact conductors of less than 750 volts to ground, they shall comply with the requirements of rule 283 (*d*–3) as to conductor sizes and sags. For trolley contact conductors of more than 750 volts to ground, the requirements for crossing over supply lines must be met, namely, grade A for direct-current trolley lines, and grade A, B, or C for alternating-current trolley lines, depending upon the voltage.

(*e*) *Signal Lines Classed as Supply Lines.*—Signal lines which are classed as supply lines (see definition 4) shall, where crossing over railways, comply with the construction requirements of rule 233. (See rule 289.)

SEC. 24. SPECIFICATIONS FOR STRENGTH AND OTHER REQUIREMENTS FOR SUPPLY LINES OF GRADES A, B, AND C

240. General Strength Requirements

(*a*) *Preliminary Assumptions.*—In the calculation of all stresses no allowance shall be made for deformation, deflection, or displacement of any part of the supporting structures.

(*b*) *Transverse Strength.*—The paragraphs which specify the transverse strength requirements for supporting structures relate to grade B construction unless otherwise stated. For grade C the transverse strength shall be not less than two-thirds of that required for grade B. For grade A the transverse strength shall be at least 50 per cent greater than that required for grade B.

(*c*) *Loading Map.*—Three districts have been outlined in which heavy, medium, and light loading, respectively, are considered to be justified by weather reports as to wind and ice and by local experience of the utilities using overhead lines. A map of the United States showing the territory falling into each class of loading is given in Appendix A.

The localities in the different groups are classed according to the relative prevalence of high wind velocity and thickness of ice which accumulates on wires, light loading being in general for places where little if any ice ever accumulates on wires.

Where high wind velocities are frequent in a given place the loading for that place may be classed as *heavy* even though ice does not accumulate to any greater extent than at some other place having less severe winds which has been classed as a *medium* loading district.

(*d*) *Modification of Loading.*—In the absence of any action by the administrative authority fixing the loadings for any given jurisdiction the classification of loadings shown on the map in Appendix A shall be considered to apply unless the party or parties responsible for the lines concerned assume some modification of the same, based upon local experience, or weather records, or both. These modifications shall be subject to review by the administrative authority.

In case a State is redistricted by State administrative authority, so as to meet local weather conditions better than the map of Appendix A, a grade of loading above heavy may be used, if necessary, to meet such local conditions.

241. Calculation of Stresses in Conductors

In computing the longitudinal stresses upon conductors and their supports, and the sags corresponding to given limiting stresses in conductors, the loading shall be assumed as one of the following, according to climatic conditions of the locality concerned.

(1) *Heavy Loading* (*H*).—The resultant loading, due to the weight of the conductor plus the added weight of a layer of ice one-half inch in radial thickness, combined with a transverse horizontal wind pressure of 8 pounds per square foot on the projected area of the ice-covered conductor, shall be called heavy loading.[4] The minimum temperature shall be assumed as 0° F.

(2) *Medium Loading* (*M*).—The resultant loading equal to two-thirds that specified in (1) above, but in no case less than 25 per cent in excess of the weight of the conductor, shall be called medium loading. The minimum temperature shall be assumed as 15° F.

Only with copper conductors of 400 000 circular mils or larger size or with very large conductors of other material is the resultant loading less than 25 per cent in excess of the conductor weight.

(3) *Light Loading* (*L*).—The resultant loading, equal to two-thirds that specified in (2) above or four-ninths that of (1), but in no case less than 25 per cent in excess of the weight of the conductor, shall be called light loading. The minimum temperature shall be assumed as 30° F.

Only with copper conductors of No. 000 or larger size or with very large conductors of other material is the resultant loading less than 25 per cent in excess of the conductor weight. (See Table 34 of Appendix A for resultant loads on conductors.)

242. Calculation of Loads upon Line Supports

(*a*) *Assumed Vertical Loading.*—The vertical loads upon poles, towers, and cross arms shall be taken as their own weight, plus the weight of the ice-covered conductors supported. The thickness of ice shall be taken as the following:

(1) Heavy loading districts—one-half inch of ice.
(2) Medium loading districts—one-fourth inch of ice.
(3) Light loading districts—no ice.
(See Appendix B, Table 35, for vertical loads due to conductors.)

---

[4] Ice is assumed to weigh 57 pounds per cubic foot.

(*b*) *Assumed Transverse Loading.*—In computing the stresses in poles and towers the loading shall be taken as one of the following according to climatic conditions of the locality concerned:

(1) *Heavy Loading* (*H*).—A horizontal wind pressure, at right angles to the direction of the line, of 8 pounds per square inch upon the projected area of cylindrical surfaces of the conductor when covered with a layer of ice one-half inch in radial thickness and of the poles and towers without ice covering shall be called heavy loading.

(2) *Medium Loading* (*M*).—A horizontal wind pressure of two-thirds that specified in (1) above shall be called medium loading.

(3) *Light Loading* (*L*).—A horizontal wind pressure of two-thirds that specified in (2) above or four-ninths that of (1) shall be called light loading.

(See rule 272 *d* for certain signal-conductor exemptions.)

For flat surfaces the assumed unit pressure shall be increased by 60 per cent. Where latticed structures are concerned the actual exposed area of one lateral face shall be increased by 50 per cent to allow for the pressure on the opposite face; this total, however, need not exceed the pressure which would occur on a solid structure of the same outside dimensions. The results obtained by more exact calculations may be substituted for the values obtained by this simple rule, if desired.

(*c*) *Average Span Lengths.*—The calculated loads upon poles, towers, and cross arms shall be based upon the average span length of a section of line that is reasonably uniform as to height, number of wires, grade, and span length, except that the average value taken shall in no case be less than 75 per cent or more than 125 per cent of the actual average of the two spans adjacent to the structure concerned.

(*d*) *Average of Three Poles.*—A pole not individually meeting the transverse strength requirements will be permitted when reinforced by a stronger pole on either side if the average strength of the three poles meets the transverse strength requirements, and the weak pole has not less than 75 per cent of the required strength.

An extra pole inserted in a normal span for the purpose of supporting a service loop may be ignored, if desired, in the calculation of the strength of the line.

(e) *Actual Span Lengths and Pole Strengths at Crossings.*—In the case, however, of crossings over railroads or signal lines (other than those mentioned in rules 234 *b*-3 and *c*-3), the actual lengths of the two spans adjacent to the two structures concerned, and the actual strengths of the crossing poles, shall be used.

243. Strength of Steel Poles and Towers and Other Metal Supports

(a) *Loads and Limiting Stresses.*—Steel supports, steel towers, and metal poles, together with their foundations, and guys when used, shall be so designed and constructed as to withstand the stresses due to the loads assumed in rule 242 above. Under those loads the calculated stresses in the steel members and in the guys shall not exceed the following values, which are intended to be limiting unit stresses, not in excess of the yield point, beyond which the structures as a whole would be liable to failure.

Structural steel:	
Tension	27 000 pounds per square inch.
Shear	24 000 pounds per square inch.
Compression	27 000–90 L/r.
Bolts, rivets, pins:	
Shear	24 000 pounds per square inch.
Bearing	48 000 pounds per square inch.
Bending	36 000 pounds per square inch.
Guys	One-half the ultimate strength.

These values for structural steel are for material having an ultimate tensile strength between 55 000 and 65 000 pounds per square inch and a yield point not less than 50 per cent of the ultimate strength.

Guys are made of various grades of steel wire, the lowest grade generally having a strength of about 60 000 pounds per square inch, while the highest grade has a strength of 180 000 pounds or more per square inch.

(*b*) *Guys*.—The use of guys to obtain compliance with these requirements is regarded as generally undersirable. When guys are necessarily used, the steel supports or towers, unless capable of considerable deflection, shall be regarded as taking all of the stress in the direction in which the guy acts, up to their safe working load, and the guys shall have sufficient strength to take the remainder of the assumed maximum stress. (See rule 212 *c* for flexible towers.)

(*c*) *Total Minimum Strength*.—Steel towers shall have a minimum strength sufficient, if all conductors are removed, to withstand a transverse force three times that computed for the tower alone.

(*d*) *Foundations*.—Steel towers or poles should preferably be placed on concrete or other suitable foundations extending above the ground line. If, however, the steel is set in earth, it shall be suitably protected against injurious corrosion at and below the ground line.

Since, in many localities the soil and climatic conditions are such as to alter the strength of foundations considerably from time to time, there should usually be provided a considerable margin of strength in foundations above that which (by calculation) will just withstand the stresses under the assumption of average conditions of climate and soil.

(*e*) *Tests*.—Unless sample structures are tested, or similar structures have been tested, to assure the compliance of structures in any line with these requirements, it is recommended that structures be designed to have a computed strength at least 10 per cent greater than that required by the rule.

(*f*) *Anchor Towers*.—When steel supports or towers are used which are not capable of withstanding approximately as great a force longitudinally as transversely, anchor towers shall be placed, at intervals not greater than 10 spans, which shall be able to witstand the combined longitudinal tension of all conductors up to 10 000 pounds plus one-half the excess above 10 000 pounds.

(*g*) *Thickness of Steel.*—Steel poles or towers of grades A, B, and C shall have no less thickness of metal in members than the following:

Legs, galvanized, $\frac{3}{16}$ inch; other members, $\frac{1}{8}$ inch.
Legs, painted, $\frac{1}{4}$ inch; other members, $\frac{1}{4}$ inch.

Such steel poles or towers, including footings, shall be so constructed that all parts are accessible for inspection, cleaning, and painting, and that pockets are not formed in which water can collect. The ratio of L, the unsupported length of a compression member, to r, the least radius of gyration of the member, should generally not be greater than 150 for legs and 200 for other members having figured stresses.

The straight-line formula given under (*a*) above for the allowable stress in compression automatically limits the stresses in steel members to safe values even though the ratio L/r is greater than the values given above. In other words, for larger values of L/r, due to increasing L, the value of the stress is reduced so much that no hazard can result.

(*h*) *Protective Covering or Treatment.*—All iron or steel poles, towers, or supporting structures, and all hardware, including bolts, washers, guys, anchor rods, and similar parts of material subject to injurious corrosion under the prevailing conditions, shall be protected by galvanizing, painting, or other treatment, which will effectively retard corrosion.

244. Strength of Wood or Concrete Supports

(*a*) *New Poles.*—Wood and reinforced-concrete poles and their foundations and guys (when used) shall, when installed, be of such material and dimensions as will withstand the loads assumed in 242 above, without the stresses under these loads exceeding 50 per cent of the assumed ultimate strengths of the materials.[5]

(b) *Maintenance.*—Wood poles shall be replaced or reinforced when their strength has decreased to two-thirds that required for new installations for grades A and B construction and to one-half for grade C construction.

(c) *Selected Poles.*—Except for crossings over railroads and over signal lines (other than those mentioned in 234 b-3 and c-3), two-thirds of the moment on wood poles (calculated as in 240 and 242 above) due to transverse wind pressure may be used in finding the stresses in the poles, under the following circumstances:

(1) The poles shall be specially selected clear wood poles.

(2) They shall have dimensions not less than those listed in Tables 41, 42, and 43 of Appendix B-4. These dimensions correspond to poles usually classified as class A for grade A and as class B for grades B and C.

(3) They shall be systematically inspected and maintained by treatment, repair, or replacement in accordance with (b) above.

(d) *Minimum Pole Sizes.*—Wood poles in grades of constructions, A, B, and C shall be of selected timber free from observable defects that would decrease their strength and durability and shall have no less nominal top diameters than 6 inches, except that for grade A, heavy and medium loading, a minimum of 7 inches is required.[6]

(e) *Guys.*—When guys are used to meet the strength requirements for wood or concrete poles, they shall be considered as taking, in the direction in which they act, the horizontal component of the entire load, the poles, acting as struts, resisting the vertical component.

245. Strength of Cross Arms and Conductor Fastenings

(a) *Cross arms of Selected Yellow Pine or Fir.*[7]—The minimum cross-sectional dimensions of selected yellow pine or fir

---

[5] For method of computing strength of construction see Appendix B.

[6] See Appendix B for data for computing transverse and longitudinal strength required for line supports and illustrative applications of the same.

[7] If of other material they shall have at least equal strength.

cross arms for grades A, B, and C construction shall be as follows:

No. of pins	For grades A and B	For grade C [a]
2 or 4 pin	3 by 4 inches	2¾ by 3¾ inches
6 or 8 pin	3¼ by 4¼ inches	3 by 4 inches

[a] Grade C signal line cross arms may be 2¾ by 3¾ inches for 6 pins, and 3 by 4 inches for 10 pins.

(*b*) *Cross-arm Strength.*—Cross arms for construction of grades A, B, or C shall, when installed, withstand the vertical loads specified in rule 242 without the stress under these loads exceeding 50 per cent of the assumed ultimate strength of the material. They shall also withstand any unbalanced longitudinal loads to which they are exposed, with a limit of unbalanced tension where conductor pulls are normally balanced, of 700 pounds at the outer pin.

(*c*) *Bracing.*—Cross arms shall be securely supported, by bracing, if necessary, so as to safely support all other loads to which they may be subjected in use, including linemen working on them. Any cross arm or buck arm except the top one shall be capable of supporting a vertical load of 225 pounds at either extremity in addition to the weight of the conductors. In general, they should be maintained at right angles to the axis of the pole and to the direction of the attached conductors, and at crossovers should be attached to that face of the structure away from the crossing, unless special bracing or double cross arms are used.

Double cross arms are generally used at crossings, unbalanced corners, and dead ends in order to permit conductor fastenings at two insulators, and so prevent slipping, although single cross arms might provide sufficient strength. To secure extra strength, double cross arms are frequently used, and cross-arm guys are sometimes used.

(*d*) *Pins and Conductor Fastenings.*—Pins, ties, and other conductor fastenings for grades A, B, and C construction shall have sufficient strength to withstand the unbalanced tension in the conductor, up to a limit of 700 pounds per pin or fastening.

Tie wires or fastenings shall have no sharp edges or burrs at contacts with the conductors.

(*e*) *Height of Pin.*—The height of the pin and of the conductor fastenings and the material and cross section of the pin should be so chosen as to afford the required strength.

The method of attaching conductors by suitable tie to single, pin-type insulators mounted on 1½ by 9 inch wood pins of locust or equivalent wood will usually provide strength up to 1000 pounds conductor tension with the conductor 3.5 inches above the cross arm. Suitable steel pins afford greater strength both for the pins and for the cross arms.

246. Conductors—Material, Minimum Sizes, and Sags

(*a*) *Materials.*—All conductors of grades A, B, or C shall be of copper, aluminum (with or without steel reinforcement), copper-covered steel, or other material which will not corrode excessively under the prevailing conditions.

(*b*) *Minimum Sizes.*—Supply conductors shall not be smaller than indicated in the following table, except that longer spans may be used with any listed conductor size if the separations and clearances given in section 22 and the sags given in Appendix A are correspondingly increased.

TABLE 9.—Minimum Allowable Conductor Sizes

[A. W. G. for copper and aluminum; Stl. W. G. for steel]

Loading district	Grade	Limiting span length in feet								
		150	175	200	250	300	400	500	700	1000
MEDIUM OR HARD-DRAWN COVERED COPPER WIRES										
Heavy............	A and B	6	4	4	......	2	......	......	......	......
	C	8	6	4	......	2	......	......	......	......
Medium..........	A	6	4	4	......	2	......	......	......	......
	B	8	6	4	......	2	......	......	......	......
	C	8	6	4	......	2	......	......	......	......
Light.............	A	6	6	4	......	2	......	......	......	......
	B	8	6	6	......	2	......	......	......	......
	C	8	8	6	......	2	......	......	......	......
MEDIUM OR HARD-DRAWN BARE COPPER WIRES										
Heavy............	A and B	6	4	4	......	4	2	2	......	......
	C	8	6	4	......	4	2	2	......	......
Medium..........	A	6	6	4	......	4	4	2	2	00
	B	8	6	4	......	4	4	2	2	00
	C	8	6	4	......	4	4	2	2	00
Light.............	A	6	6	6	......	4	4	4	2	1
	B	8	6	6	......	4	4	4	2	1
	C	8	8	6	......	4	4	4	2	1
SOFT-DRAWN COPPER WIRES										
Heavy............	A	4	2	1	......	......	......	......	......	......
	B	4	2	2	......	......	......	......	......	......
	C	6	2	2	......	......	......	......	......	......
Medium..........	A and B	4	4	2	1	......	......	......	......	......
	C	6	4	2	1	......	......	......	......	......
Light.............	A, B, and C	6	4	4	2	1	......	......	......	......

TABLE 9—Continued

STEEL WIRES

Loading district	Grade	Limiting span length in feet	
		150 or less	Exceeding 150
All	A and B	6	4
All	C	9	6

ALUMINUM WIRES—WITHOUT STEEL REINFORCEMENT

All	A, B, and C	1	0

ALUMINUM WIRES—WITH STEEL REINFORCEMENT

All	A, B, and C	6	4

NOTE.—For sizes and material requirements of supply service leads see rule 219.

Lightning-protection wires paralleling the line conductors shall be regarded, in respect to size, material, and stringing requirements, as supply conductors with which they are associated.

(c) *Sags and Maximum Tensions.*—In grades of construction A, B, and C, conductors of hard, medium, and soft-drawn copper and steel shall have normal sags at 60° F and no wind as nearly as practicable to those given in the tables of Appendix A.

Less sags than tho se listed may be used if pins, fastenings, cross arms and poles of sufficient strength to withstand the corresponding increase in longitudinal tension are used, but sags shall not be so decreased from the tabulated values that, under the maximum assumed loading for the district, the tension will exceed 50 per cent of the breaking strength of the conductor concerned for grades A and B construction, and 60 per cent for grade C construction.

The sags given for copper in the tables are based upon experience and are designed to give the best results from the standpoint of safety and continuity of service.

(*d*) *Sags Limited.*—In order to minimize the danger from wires swinging together and to permit the moderate pin spacings and cross-arm spacings sanctioned by modern good practice in overhead line construction, it is necessary to assign a limit to the sag, and hence to the recommended length of span of the smaller-sized wires, as indicated by the blank spaces in the tables. Longer spans may, however, be used with any listed conductor size if separations and clearances (given in sec. 22), and the sags given in Appendix A are correspondingly increased. It is recommended that medium-hard drawn copper wire [8] be used instead of soft in new construction, especially for sizes smaller than No. 2.

Soft copper wire has a yield point less than one-half that of medium-drawn copper, and hence stretches permanently with a correspondingly lighter loading of ice and wind.

Copper wire does not have so sharply defined a yield point as steel, but for practical purposes the yield point may be considered as that point beyond which the wire is permanently elongated and the sag permanently increased. If the wire when first strung is pulled to a tension approximately equal to half its breaking strength and then released and tied, its yield point is thereby raised and it will be less likely to stretch and its sag to increase materially under moderate loading of ice and wind.

(*e*) *Taking Up Slack.*—Slack should be taken up when, because of the permanent elongation of the wire or movement of supporting structures, the initial sags have so increased that the clearances or separations of conductors are materially below the requirements of the rules. As soft copper stretches more than medium or hard, the taking up of slack will be necessary chiefly in lines where soft wire is used.

247. Line Insulators for Grades A and B Construction

(*a*) *High-Voltage Insulators.*—Insulators for operation on supply lines at voltages exceeding 7500 volts shall be of

[8] Conforming to the specifications of the American Society for Testing Materials.

porcelain or other material which will give equally good results in respect to mechanical and electrical performance and durability and should be marked by the maker with a classification number and maker's name or trade-mark, the marks being so applied as not to reduce the electrical or mechanical strength of the insulator.

(*b*) *Strain Insulators.*—Where strain insulators are used they shall have the same electrical strength as other insulators on the line when under the normal mechanical stresses to which they may be subjected.

(*c*) *Insulators at Grounded Structures.*—Wherever wood pins and cross arms or other ungrounded supports are used within five spans of a crossing span with line conductors at the crossing span attached to grounded metal pins, grounded cross arms, steel bridges, steel towers, or other grounded structures, the insulators at the grounded supports shall be capable of withstanding without flash-over a voltage 50 per cent higher than those used at adjacent underground supports.

Where the supporting structures for the crossing span are the same with respect to grounding as for the other parts of the line, the insulators used may also be the same.

(*d*) *Ratio Flash-over to Puncture Voltage.*—Insulators shall be so designed that their dry flash-over voltage is not more than 75 per cent of their puncture voltage at a frequency of 60 cycles per second.

(*e*) *Factory Tests.*—Insulators shall be capable of withstanding without flash-over at a frequency of 60 cycles per second the values given in the following table:

TABLE 10.—Test Voltage Requirements

Voltage of service circuit	Test Voltage	
	Dry	Wet
750	5 000	3 500
2300	11 000	8 000
4000	17 000	13 000
6600	27 000	20 000
7500	30 000	22 000
11 000	40 000	30 000
22 000	75 000	55 000
33 000	105 000	75 000
44 000	135 000	95 000
55 000	160 000	115 000
66 000	185 000	135 000
88 000	235 000	170 000
110 000	285 000	200 000
150 000	375 000	225 000
200 000	490 000	250 000

By the term "wet" is meant a condition equivalent to a precipitation of one-fifth inch of rain per minute at an angle of 45 degrees to the axis of the insulator.

Each insulator for use on lines operating at voltages in excess of 15 000 volts shall be subjected to a routing factory dry test at the values given in Table 10 above for a period of 3 minutes at a frequency of 60 cycles or to any other test sanctioned by good modern practice, such as high-frequency tests.

(*f*) *Protection Against Arcing.*—In installing the insulators and conductors such precautions as are sanctioned by good modern practice shall be taken to prevent as far as possible any arc from forming or to prevent any arc which might be formed from injuring or burning any parts of the supporting structures, insulators, or conductors which might render the conductors liable to fall.

14112°—21——9

248. Special Transverse-Strength Requirements

(*a*) *Alternate Construction in Special Cases.*—In the case of structures of grades A or B construction where because of very heavy or numerous conductors or relatively long spans the transverse strength requirements of this section can not be met except by the use of side guys or special structures, and it is physically impracticable to employ side guys, the transverse strength requirements may be met by side-guying the line at each side of and as near as practicable to the crossing or other transversely weak structure, and with a distance between such side-guyed structures of not over 800 feet: *Provided:*

(1) The side-guyed structures for each such section of 800 feet or less shall be constructed to withstand the calculated transverse load due to wind on the supports and ice-covered conductors, on the entire section between the side-guyed structures.

(2) The line between such side-guyed structures shall be substantially in a straight line and the average length of span between the side-guyed structures shall not be in excess of 150 feet.

(3) The entire section between the transversely strong structures shall comply with the highest grade of construction concerned in the given section, except as to the transverse strength of the intermediate poles or towers.

(*b*) *Strength of Cross Arms and Pins.*—The cross arms, insulator pins, and conductor fastenings connected to the structure at each end of the transversely weak section in lines of grades A and B construction shall be such as to withstand, under the conditions of loading prescribed in rule 241 an unbalanced load equivalent to the combined pull in the direction of the transversely weak section of all the conductors supported up to 10 000 pounds plus one-half the excess for grade A, or plus one-fourth the excess for grade B.

If the unbalanced tension in any conductor does not exceed 1000 pounds, the necessary strength will usually be provided by the use of single wood pins, and if the tension does not exceed 2000 pounds, by the use of double wood pins provided the lever arm of the pin does not exceed 3.5 inches. (See Appendix A for tensions.)

249. Special Longitudinal Strength Requirements for Sections of Grades A and B Construction in Lines of a Lower Grade of Construction (or Adjacent to Angles or Dead Ends)

(*a*) *Required Strength.*—The supporting structures (including poles, towers, cross arms, insulator pins, and conductor fastenings) for the ends of the higher grade section of the line shall be constructed to withstand without failure under the conditions of loading prescribed in rule 241 a longitudinal load equivalent (except as noted in *d*) to the combined pull in the direction of this section of all the conductors and wires supported, the pull of each conductor or wire being taken as the tension therein due to the prescribed loading. Where it is difficult to increase the longitudinal strength, the longitudinal stresses shall be reduced by increasing the conductor sags. This may require greater conductor separations. (See rules 221, 222, and 223.)

(*b*) *Flexible Supports.*—When supports of the section of higher grade are capable of considerable deflection in the direction of the line, as with wood or concrete poles, or some types of metal poles and towers, it may be necessary to increase the normal clearances specified in rule 220 or to provide head guys or special reinforcement to prevent such deflection. So-called flexible steel towers or frames if used at such locations shall be adequately reinforced to meet the requirements of (*a*) above.

(*c*) *Methods of Providing Strength.*—The requirements of (*a*) are usually met by placing supporting structures of the required longitudinal strength at either end of the higher grade section of the line.

Where this is impracticable the supporting structures of the required longitudinal strength may be located one or more span lengths away from the section of higher grade, within 500 feet on either side and with not more than 800 feet between the longitudinally strong structures, provided such structures and the line between them meet the requirements, as to transverse strength and stringing of conductors, of the highest grade occurring in the section, and provided that the line between the longitudinally strong structures is approximately straight or suitably guyed.

The requirements may also be met by distributing the head guys over two or more structures on either side of the crossing, such structures and the line between them complying with the requirements for the crossing as to transverse strength and as to conductors and their fastenings.

(*d*) *Modified Strength Requirements for Heavy Lines.*—In cases where the line is approximately straight on both sides of the section of higher grade and in line with it, the strength of each pole or each cross arm shall be such as to withstand the combined stress in the conductors up to 10 000 pounds combined pull, plus one-half the excess above 10 000 pounds for grade A, and plus one-fourth the excess for grade B, if the line on one or both sides of the special construction should fail. In cases where, due to change of direction of the line or because of dead ends the longitudinal stresses in the conductors of the stronger section are not even normally balanced by the conductors of the line beyond this construction, the construction shall be such as to withstand the total combined stress.

Where the section of higher grade is not in line with the line beyond this section, suitable guys shall be placed to withstand the resulting transverse forces.

SEC. 25. REQUIREMENTS FOR SUPPLY LINES, INCLUDING ELECTRIC RAILWAY FEEDERS

250. Compliance with Other Rules

(*a*) *Grade B or C Construction.*—In addition to the requirements of sections 20, 21, and 22, the requirements of this section shall be met by all supply lines in urban and rural districts where a definite grade of construction (B or C) is required by section 23, except in the important cases of crossings over railways or signal lines and conflicts and the joint use of poles, which are covered by sections 26 and 27.

(*b*) *Special Strength.*—Special longitudinal strength requirements are made in rule 249 for crossings of supply lines of less than 7500 volts and of cabled supply lines exceeding 7500 volts over supply lines of more than 7500 volts in urban districts.

(*c*) *Dead Ends.*—Where supply lines of more than 7500 volts in urban districts come to dead ends or to changes in line direction (even where no crossing exists) they shall have construction complying with the longitudinal strength requirements of rule 249.

(*d*) *Clearances.*—For clearances of conductors and wires above roadways, railways, and footways, and from other conductors and wires, see rules 220, 257, and 258.

251. Supply Lines in Urban Districts

(*a*) *Lines of Less than 750 Volts.*—Supply lines of less than 750 volts in urban districts, where alone, or where crossing over, conflicting with, or where higher on common poles with, other supply lines of less than 750 volts need only comply with the general requirements of sections 20, 21, and 22.

If the lower supply lines have a voltage greater than 750 volts and are not in cable having permanently grounded continuous metal sheath or armor and installed in compliance with rules 274 (*c*), (*d*), (*e*), (*f*), both lines shall comply with the requirements of grade C; if the lower supply lines are of more than 7500 volts and not in such cable, both lines shall comply with the requirements of grade B.

(*b*) *Lines of Voltages between 750 and 7500.*—Supply lines of voltages between 750 and 7500 in urban districts, where alone, or where crossing over, or conflicting with, or where higher on common poles with, other supply lines of not more than 7500 volts shall comply with the construction requirements of grade C, as given in section 24, unless the supply lines are in cable having permanently grounded continuous metal sheath or armor and are installed in compliance with rules 274 (*c*), (*d*), (*e*), (*f*), in which case no grade is required.

If the lower supply lines have a voltage greater than 7500 and are not in such cable, both shall comply with the construction requirements of grade B.

(*c*) *Lines of More than 7500 Volts.*—Supply lines of more than 7500 volts in urban districts where alone, or on the same poles with other supply lines of any voltage, or crossing or conflicting with such lines, shall comply with the construction requirements of grade B, except as covered in the next paragraph.

Such lines if in cable having permanently grounded continuous metal sheath or armor and installed in compliance with rule 274 need only comply with the construction requirements of grade C.

252. Supply Lines in Rural Districts

(*a*) *No Grade.*—Where supply lines of any voltage in rural districts are not concerned with crossing of railways or signal lines, or conflicts or joint use of poles with signal lines, no grade of construction is required for conductors or supports, except as noted in (*b*) below. Such lines are subject only to sections 20, 21, and 22 for isolation, guarding, clearances, and pole arrangement, etc.

(*b*) *Grade C.*—When either of two supply lines in rural districts, one of more than 7500 volts and the other of less than 750 volts, crosses, conflicts with, or has common poles with the other, the upper one shall be of grade C, unless the line of higher voltage is in cable having permanently grounded continuous metal sheath or armor and is installed in compliance with rules 274 (*c*), (*d*), (*e*), (*f*).

253. Constant-Current Lines

Where supply lines only are concerned, constant-current lines are included with constant-potential lines and graded by the nominal full-load voltage of the circuit concerned.

254. Common Use of Poles by Different Supply Lines

(*a*) *Relative Levels.*—Poles or towers used in common by supply lines of different voltage classifications, including trolley feeders, whether owned by the same or different utilities, shall have all supply lines arranged as to relative levels, separations, and clearances according to the requirements of section 22. In general the lines of higher voltage should be placed above those of lower voltage, and this arrangement will often avoid the necessity for increasing the grade of construction of the cross arms, pins, and fastenings for the lower-voltage conductors.

(*b*) *Relative Levels of Wires of Different Utilities.*—Where poles are used in common by separately owned utilities each of which may have supply conductors of different voltages on the same pole, supply conductors of a lower voltage of one utility may be placed at a higher level than those of a higher voltage of another utility in order to admit of keeping each utility's supply conductors in adjacent positions on the pole, provided that either (1) conductors of a lower voltage classification shall never be at a higher level than those of a higher classification, unless on the opposite side of the pole or (2) that a vertical spacing not less than 4 feet is maintained between the nearest line conductors of the respective utilities, and this spacing be identified if necessary as a division space.

(*c*) *Grade of Construction.*—Poles or towers used in common by supply lines, as noted in (*a*), shall have the grade of construction determined by section 23 for the highest voltage lines carried on such poles or towers, all conductors of all voltages being included in the computations of loads on the poles or towers.

The cross arms, pins, and fastenings of conductors on poles or towers used in common by supply lines, as noted in (*a*), shall have the grade of construction determined by section 23 for the lines carried by the cross arm, pin, or fastening in question, according to their relation to other lines carried on the poles or towers.

(*d*) *Conductor Size and Sag.*—The size and initial sag of each conductor shall be determined by its own voltage and the grade of construction required for it, according to its relation to other conductors carried on the pole or tower.

The different conductors on a commonly used pole may therefore be subject to different grades of construction requirements, the grade necessary for any cross arm or pole being the highest required by section 23 for any conductor carried.

(*e*) *Trolley Wires.*—Where a trolley contact conductor is supported on a commonly used pole, it shall be included in the computation of transverse stress on the structure.

255. Electric Railway Feeders and Contact Conductors

(*a*) *Trolley Feeders as Supply Lines.*—Except where specifically exempted in these rules (as for clearances and elevation in rules for common use of poles in this section and in section 22) trolley feeders shall be considered and constructed in all respects as supply lines of equal voltage.

(*b*) *Third Rails.*—Third rails shall be protected where not on fenced rights of way by overlapping guards composed of wood or other suitable material.

(*c*) *Trolley Contact Conductor Supports.*—All overhead trolley contact conductors shall be so supported and arranged that the breaking of a single conductor fastening will not allow the trolley conductor or live span wire or current-carrying connections to come within 10 feet from the ground or from any platform accessible to the general public. Span-wire insulation for trolley contact conductors shall comply with rule 213 (*g*).

(*d*) *High-Voltage Contact Conductors.*—Every trolley contact conductor of more than 750 volts in urban districts (where not on fenced right of way) shall be so suspended that if broken at a single point it can not fall within 12 feet from the ground or any platform accessible to the general public.

(*e*) *Supply Lines over Trolley Contact Conductors.*—Supply conductors carried over trolley contact conductors shall conform to the same requirements as where crossing over supply lines of equal voltage, whether in urban or rural districts.

256. Electric Railway Construction

(*a*) *Assuring against Loss of Power at Railway Crossings.*—Unless electric-railroad systems are protected by interlocking derails or gates at grade crossings with interurban or other heavy or high-speed railroad systems the trolley-contact conductors shall either be arranged with live trolley guards of suitable construction or shall be at the same elevation above their own tracks throughout the crossing and next adjoining spans, with catenary construetion for crossing spans exceeding 100 feet.

(*b*) *Guards under Bridges.*—Where passing under steel bridges that are not sufficiently elevated to prevent a trolley pole from making contact with the bridge in case it leaves the contact conductor, a substantial inverted trough or other guard of insulating material shall be so installed as to prevent the trolley pole from making an electrical connection between the contact conductor and the bridge structure. (See rule 229 *e*.)

(*c*) *Construction at Railway Crossings.*—Trolley-contact conductors and feeders and their supporting structures, where crossing over railways, shall conform to the strength requirements specified for supply lines under section 24 and rule 260. The clearance of trolley construction supports from the rails of railways crossed over shall comply with the requirements for supply-line supports under rule 211 (*d*).

(*d*) *Strength of Construction in Urban Districts Generally.*—Trolley-contact conductors, feeders, and their supports, in urban districts, shall comply with the strength requirements for supply lines of equal voltage. Direct-current circuits of more than 750 volts to ground where at higher levels and crossing over, conflicting with, or higher than and having joint poles with, signal lines shall comply with the requirements of grade A. (See rule 234 *b*–3 for special cases.)

257. Wire Clearances above Railways, Roadways, and Footways

The clear space between the lowest overhead trolley-contact conductor or feeder, or guy, span, or messenger wire and the surfaces of rails, streets, highways, or alleys over which the former passes shall not be less than the following at 60° F, with no wind. (See also rule 220.)

(1) Above track rails of electric and other railways where brakemen are permitted on top of cars:

	Feet
Trolley contact conductors	22
Trolley feeders paralleling the contact conductors on the same street or highway	25

Where 21 feet has been established in any community instead of 22 feet for trolley-contact conductor clearance, this may be continued, if carefully maintained.

(2) Above streets or alleys, roadways, or footways, including track rails of railways where brakemen are not permitted on top of cars the trolley-contact conductors, when of not more than 750 volts to ground, shall have a minimum clearance of 16 feet, and when of more than 750 volts to ground shall have a minimum clearance of 18 feet.

This clearance is the minimum clear height in the middle of the contact-conductor span. The point of support at the pole structure should be not less than 2 feet higher, thus allowing for maximum sag in span wire and trolley-contact conductor at 60° F.

(3) Where subways, tunnels, or bridges require it, a less clearance of contact conductor above ground may be used locally, and the trolley-contact conductor should be very gradually graded from the regular construction down to the reduced elevation.

258. Clearances of Contact Conductors from Other Wires at Crossings

The clear space between the trolley-contact conductor and the lowest overhead conductor or wire crossing above shall be not less than the following at 60° F with no wind.

	Feet
Signal lines	4
Supply lines, 0 to 750 volts	4
Supply lines, 750 to 7,500 volts	6
Supply lines, 7,500 to 50 000 volts	6
Guy, span, and messenger wires and service loops	4
If trolley-contact conductor is of more than 750 volts, no conductor should cross at less than	6
Unless the crossover conductors are beyond the reach of a trolley pole leaving the contact conductor or are suitably protected against damage from a trolley pole leaving the contact conductor, the clearance from trolley-contact conductors of less than 750 volts should be not less than	6

Trolley feeders are exempt from a clearance requirement from contact conductors at the same nominal potential and of the same system.

For clearance increases see rule 220.

SEC. 26. CROSSINGS OF SUPPLY LINES OVER RAILWAYS

260. Grades of Construction

Overhead supply lines (or signal lines which have taken on the character of supply lines) crossing over railways shall comply with the construction requirements of grade A, except when over spurs, branches, or other minor tracks only, in which case they shall comply with the construction requirements of grade B. (See rule 233 for full statement.)

261. Compliance with Other Rules

Such overhead supply lines shall comply as to conductor sizes, materials, and sags, and as to materials, sizes, and strength of supporting structures and attachments with the requirements of section 24; as to separations, clearances, and relative levels of conductors and wires on the line itself, with the requirements of section 22; as to guys and their insulators, with the requirements of rules 212 and 213 and in general with the requirements of sections 20 and 23.

262. Pole Clearance to Rail

Poles or towers supporting the crossover spans of overhead supply lines over railways shall, unless physical conditions or municipal requirements prevent, have side clearance not less than 12 feet from the nearest track rail, except that at sidings a clearance not less than 7 feet may be allowed. At loading sidings sufficient space shall be left for a driveway.

If overhead lines of the railway are crossed over, the pole or tower structures of each line concerned in the crossover shall have clearances from the conductors of the other line as required by rule 221 or 227 (*a*), whichever applies.

263. Wire Clearance above Rail

(See rule 220 *a*, where the same requirements are given in tabular form.)

The clear space between the lowest overhead supply line conductor or wire and the heads of rails above which the former cross shall not be less than the following at 60° F, with no wind, where the conductor or wire has fixed supports and the span does not exceed 150 feet.

(*a*) *Clearances Where Men are Permitted on Cars.*—Above track rails of railways handling standard freight cars where brakemen are permitted on top:

(1) Supply lines of less than 300 volts to ground, overhead ground wires, and their guy, messenger, and span wires, 27 feet.

This may be reduced to 25 feet where lines are paralleled by trolley contact conductors on same street or highway.

(2) Supply lines, 300 volts to ground to 15 000 volts, 28 feet.

This may be reduced to 25 feet where lines are paralleled by trolley contact conductors on same street or highway.

(3) Supply lines, 15 000 to 50 000 volts, 30 feet.

For conductors of more than 50 000 volts the given clearance shall be increased at the rate of 0.5 inch per 1000 volts excess.

(4) Trolley contact conductors, 22 feet.

In communities where 21 feet has been established this clearance may be continued if carefully maintained. The elevation of the contact conductor should be the same in the crossing and next adjacent spans.

(b) *Clearances Where Men are not Permitted on Cars.*—Above track rails of electric and other railways where brakemen are not permitted on top of cars, the clearances shall be at least 18, 20, 22, and 16 feet, respectively, in the four cases given above.

The given trolley clearance (16 feet) is the minimum clear height in the middle of the trolley contact conductor span, and the point of support at the pole structure should be at a height of not less than 18 feet above the track rail for trolley contact conductors of not more than 750 volts to ground, thus allowing 2 feet for the total maximum sag at 60°F. in span wire and trolley contact conductor. For trolley contact conductors of more than 750 volts to ground, the clearance shall be increased by 2 feet.

(c) *Increased Clearance for (a) and (b).*—The clearances of (a) and (b) apply to spans not exceeding 150 feet. For longer spans they shall be increased by 1 inch for each 10 feet of the excess between 150 and 300 feet and by 1 inch for each 20 feet of the excess beyond 300 feet.

264. Crossover Wire Clearances to Railway Wires

(See rule 220 *c*, where the same requirements are given in tabular form.)

The clear space between the lowest overhead supply line conductor or guy or span wire crossing over any conductor or wire concerned in the operation of the railway (except for crossings between conductors and guy or span wires on the same poles, for which see rule 221) shall not be less than given below at 60° F, with no wind, where the upper conductor or wire has fixed supports (pin or strain-type insulators), and the sum of the distances from the point of intersection to the nearest supporting structure of each span does not exceed 100 feet. (When crossing over supply conductors of the railway in excess of 7500 volts, the clearances of rule 220 *c* apply.)

(1) Above signal conductors (of railways):

	Feet
Supply lines, 0 to 750 volts	4

(This may be reduced to 2 feet if the crossing is not within 6 feet of any pole concerned in the crossing and the voltage is not more than 300 volts.)

Supply lines, 750 to 7500 volts	4
Supply lines, 7500 to 50 000 volts	6
Service supply connections (0 to 750 volts)	2
Guy, messenger, and span wires	2

(2) Above supply conductors of not more than 7500 volts (defined as such when more than 400 volts to ground and supplying railway signal systems):

	Feet
Supply lines, 0 to 750 volts	2
Supply lines, 750 to 7500 volts	2
Supply lines, 7500 to 50 000 volts	4
Guy, messenger, and span wires [9]	4

265. Increase of Clearances in Special Cases

(*a*) *Clearance Increase for Long Spans.*—The clearances of rule 264 shall be increased where the sum of the distances from the point of intersection to the nearest supporting structure of each span exceeds 100 feet by 2 inches for each 10 feet of the excess between 100 and 200 feet, and by 2 inches for each 20 feet of the excess beyond 200 feet.

(*b*) *Clearance Increase for High Voltage.*—The clearances of rule 264 shall be increased, where the supply line voltage exceeds 50 000 volts, by 0.5 inch per 1000 volts of the excess.

(*c*) *Clearance Increase for Suspension Insulators.*—The initial clearances, where the upper line at a grade A or B

---

[9] May be reduced to 2 feet when voltages do not exceed 750 volts.

crossing over track rails or signal lines is supported by suspension insulators, shall be sufficient to prevent the minimum clearances of rules 263 and 264 from being reduced through the breaking of a conductor in either adjoining span by more than 10 per cent over rails or by more than 25 per cent over conductors or wires.

The arrangement of insulators so that they are restrained from displacement toward the crossing will obviate necessity of any increase over the clearances given in rules 263 and 264.

(*d*) *Increases Cumulative.*—The above increases are cumulative when more than one applies.

266. Protection against Conductor Breakage

(*a*) *Splices and Taps.*—Splices shall not be made in the crossing span and preferably not in the adjacent spans, which are depended upon for withstanding the longitudinal stress of the crossing conductors. If a splice or tap is made in any conductor in the span next to the crossover span, it shall, where practicable, be placed at a point nearer to the crossover support than is the nearest conductor crossed over.

It is not the intent of this rule to prohibit the installation, in either the crossing or adjacent spans, of reliable protective devices of the drop-out disconnector type that require making a joint in the conductor.

(*b*) *Falling Trees.*—The crossing span and the next adjoining spans, so far as practicable, shall be kept free from overhanging or decayed trees which might fall into the line. (See also rules 209 and 211.)

267. Special Short-Span Crossing Construction

In cases where the crossover span is constructed of such height and so arranged that, in the event of breakage, no part of any conductor concerned in the crossing can come within 15 feet of the ground or of the rails, the requirements specified in section 24 as to conductor size and sags are, so far as they are required by reason of the railroad crossing, waived, provided that a permanently grounded guard arm is installed at each crossover support in such manner as to prevent conductors which break in either adjacent span from swinging back into the space between the crossover supports.

268. Underground Lines Crossing Under Railways

Underground supply lines crossing railways shall comply with the requirements of sections 20 and 29, and particularly of rules 290 and 295. This requires that manholes, pull boxes, and terminals shall, where practicable, be located away from the roadbed, and that conductors and cables carried underground under railways shall be placed in suitable ducts.

SEC. 27. SUPPLY LINES OVER SIGNAL LINES AND JOINT USE OF POLES

270. Special Requirements and Compliance with Other Rules

(a) *Grade of Construction.*—Overhead supply lines crossing over signal lines under the circumstances noted in rule 234 shall comply with grades of construction A, B, or C, as noted in the rule referred to.

(b) *Compliance with Other Rules.*—Such overhead supply lines shall comply as to conductor sizes, materials, and sags and as to materials, sizes, and strength of supporting structures and attachments with section 24; as to separations and clearances of conductors and wires of the supply line itself with the requirements of section 22; and as to guys and their insulators with the requirements of rules 212 and 213.

(c) *Where Concerned with Other Overhead Lines or with Railways.*—Such overhead supply lines, where also concerned at the crossover with crossings, conflicts, or common use of poles with other overhead lines than the signal lines crossed over, or with a railway crossing, shall comply also with the requirements of rule 230 as to relative levels and with 231 to 235 as to character of construction, and with other rules of this section which apply to these conditions.

(*d*) *Pole Clearance.*—The pole or tower structures of each line concerned in the crossover shall have clearances from the conductors of the other line, as required by rule 221 or 227 (*a*), whichever applies.

(*e*) *Wire Clearance above Signal Wires.*—The clear space between the lowest overhead supply line conductor or guy, messenger, or span wire, crossing over any signal line conductor or guy, span, or messenger wire (except for crossings between conductors and guy, messenger, or span wires on the same pole, for which see rule 221), shall not be less than given below, at 60° F, with no wind, where the upper conductor or wire has fixed supports (pin or strain-type insulators), and the sum of the distances from the point of intersection to the nearest supporting structure of each span does not exceed 100 feet.

(1) Above signal conductors:	Feet
Services, 0 to 750 volts	2
Supply lines, 0 to 750 volts	4
This may be reduced to 2 feet, if the crossing is not within 6 feet from any pole concerned in the crossing and the voltage is not more than 300 volts.	
Services and supply lines, 750 to 7500 volts	4
Services and supply lines, 7500 to 50 000 volts	6
Guy, messenger, and span wires	2
(2) Above guy, span, or messenger wires (of signal lines):	
Supply lines, 0 to 750 volts	2
Supply lines, 750 to 50 000 volts	4
Guy, messenger, and span wires	2

(*f*) *Clearance Increases.*—The increases of clearances for longer spans, higher voltages, and for suspension insulators shall be as given in rule 220 (*d*).

(*g*) *Special Requirements.*—Special longitudinal strength requirements are given in rule 249.

Requirements for protection against conductor breakage are given in rule 266.

271. Supply Lines Conflicting with Signal Lines

(a) *Strength of Construction.*—Where supply lines are at higher levels and conflict with signal lines, the requirements of rule 270 apply in general to the conflicting supply lines, just as they apply where the supply lines cross over the same signal lines.

(b) *Avoidance of Conflict.*—Two parallel pole lines, either of which carries supply circuits, shall, where practicable, be so separated from each other that neither conflicts with the other. (See rule 272 *a*.)

272. The Joint Use of Poles by Signal and Supply Lines—Supply Lines above Signal Lines

(a) *Avoidance of Conflict by Joint Use.*—The separation of two parallel pole lines, one of which carries supply conductors and the other signal conductors, shall, where practicable, be sufficient so that neither conflicts with the other, and if within conflicting distance they shall be separated as far as practicable.

If separation beyond conflicting distance is impracticable the choice between a joint pole line and separate conflicting lines depends on the voltage of the supply circuits, the total number and weight of conductors, the tree conditions, number and location of branches and service drops, availability of right of way, etc., as affecting the relative safety attainable at reasonable cost.

Where signal lines are concerned only with supply lines at voltages not exceeding 5000 volts between conductors (or 2900 volts to neutral or ground) or constant-current circuits not exceeding 7.5 amperes, joint construction is recommended in preference to separate pole lines on the same street or highway (except sometimes in rural districts) unless the number of conductors is very large or the character of the circuits makes joint use undesirable.

Where signal lines are concerned with supply lines of more than 5000 volts between conductors (or 2900 volts to neutral or ground) or constant-current circuits carrying more than 7.5 amperes, joint use is not recommended in preference to separate pole lines, except (1) where it is impracticable to separate the lines sufficiently to avoid a conflict, or (2) where there would be a considerable number of service drops or branches from one line which must cross the other.

In any event, however, joint use is preferable to the overbuilding of one pole line by another.

(*b*) *Strength of Poles.*—Poles used jointly by supply lines and signal lines with the supply lines above shall have the highest grade of construction specified in rule 234 according to the voltage and character of the various lines carried by the pole.

Where the signal lines are used exclusively in the operation of supply lines the grade of construction need not be that required above but the lines shall occupy the same relative positions noted under (*f*) below.

(*c*) *Conductor Supports.*—The strength of cross arms, pins, and fastenings shall conform to the highest grade of construction required for the lines carried by the particular cross arm concerned, according to rule 234. This may sometimes be a lower grade than that required for the pole or tower by reason of other lines carried on higher cross arms.

(*d*) *Special Provision Regarding Transverse Strength.*—In calculating the transverse forces upon poles carrying supply conductors above signal conductors, where no supply conductors are below signal conductors, and where the reduction in transverse moment given in rule 244 (*c*) is not used, the number of signal conductors upon which the transverse force is calculated shall be taken as only one-half their total number provided that they are smaller than No. 8 Stl. W. G. if steel or No. 6 A. W. G. if copper.

There are two reasons for this exception: (1) Signal conductors of small size and strung to small sags are more liable to break and relieve transverse load than are larger supply conductors so strung; (2) joint use of poles will be encouraged and thus hazards be avoided which would exist were two separate (and frequently conflicting) pole lines used, often with numerous crossings over service drops.

(e) *Longitudinal Stresses.*—In calculating the longitudinal stresses upon jointly used poles complying with grade A or B construction requirements where crossing over railways or over signal lines (where these crossings would of themselves require compliance with grade A or B construction of the crossover span) the tension in the signal conductors may be considered as limited to one-half their breaking strength provided they are smaller than No. 8 Stl. W. G. if of steel, or No. 6 A. W. G. if of copper, regardless of how small the initial sags of the signal conductors at 60° F.

(f) *Clearances, Separations, and Relative Levels.*—(1) The clearances and separations of supply and signal conductors on jointly used poles as well as the relative levels are covered in detail in rules 224 and 230. In general, signal lines for public use should be not less than 4 feet below supply lines.

Where signal lines are below supply lines the requirements for grade A, B, or C strength of the signal-line cross arms, pins, and fastenings are avoided.

The establishment of standardized levels in any given community, as recommended by rule 230, facilitates the extension of lines and the safety of the public and workers by permitting the desired relative levels and clearances to be readily obtained on jointly used poles as well as in crossings and conflicts.

(2) Span wires or brackets for supporting lamps or trolley-contact wires on jointly used poles may have less clearance from signal attachments than specified in the foregoing, but in no case shall the clearance be reduced below the following: From span wires or brackets for lamps or trolley-contact wires to cross arms carrying signal conductors 2 feet, to

messenger wire carrying signal cable 1 foot, to terminal boxes of signal cable, 1 foot.

Where it is not practicable to obtain a clearance of one foot to terminal boxes of signal cable, all metal parts of terminals shall have the greatest practicable separation from fixtures or span wires, including all supporting screws and bolts of both classes of attachments.

273. The Joint Use of Poles by Signal and Supply Lines—Signal Lines Above Supply Lines

(This relation of levels is not in general desirable, and should be avoided where practicable.)

(*a*) *Strength Requirements.*—Poles or towers used jointly by signal and supply lines, with the signal lines above the supply lines, shall comply with the requirements and rules referred to in rule 272 as well as those in this rule.

(*b*) *No Reduction.*—The grade of construction A or B where required for the signal lines, includes the size, material, and sag of conductors as well as the strength of structures required for supply lines of the same grade by section 24 with no reduction in transverse strength requirements such as is permitted by rule 272 (*d*) where supply lines are above signal lines.

(*c*) *Grade C Signal Conductors.*—Signal conductors which are required to comply with grade C construction may be smaller than grade C supply conductors, but must not be smaller nor have less sags than for grade D construction for spans up to 150 feet; for spans over 150 feet the requirements for supply conductors must be met. (See Tables 11 and 13 of rule 283 for grade D conductor sizes and sags.)

(*d*) *Minor Extensions.*—In localities where the practice of placing conductors of signal circuits for public use above supply conductors has been generally established, minor extensions with the conductors in the same relative positions and with the clearances covered by the table may be made in either system, but these extensions should not continue beyond a location at which it becomes practicable to change to the arrangement standardized by these rules.

274. The Joint Use of Poles by Cabled Supply Lines and Signal Lines

(*a*) *Requirements When Cable Is Unsheathed.*—Poles used jointly by signal lines and cabled supply lines not having permanently grounded continuous metal sheath or armor shall meet all the requirements for poles used jointly by open supply and signal lines given in rule 272.

(*b*) *Strength of Poles when Cable is Sheathed.*—Cabled supply lines having permanently grounded continuous metal sheath or armor shall be installed in compliance with (*c*), (*d*), (*e*), and (*f*) below. When the voltage of the cabled supply lines is greater than 750, the poles shall meet the strength requirements of grade C as given in section 24.

(*c*) *Messengers.*—Messengers shall be stranded and of galvanized or copper-covered steel with strengths and sags as specified in rule 283 (*f*), or if of other sizes shall not be stressed beyond half their ultimate strength when the cable and messenger are coated with one-half inch of ice and subjected to a transverse wind pressure of 8 pounds per square foot of projected area.

(*d*) *Grounding of Cable Sheath.*—Each section of cable between splices shall be suitably and permanently bonded to the messenger wire at not less than two places. The messenger wire shall be grounded at the ends of the line and at intermediate points not exceeding 800 feet apart. (See section 9 for method.)

(*e*) *Splices.*—Splices in the cable shall be so made that their insulation is not materially weaker than the remainder of the cable. The sheath or armor at the splice shall be made electrically continuous.

(*f*) *Insulation.*—The conductors of the cable shall be so insulated as to withstand a factory potential test of at least twice the operating voltage at operating frequency applied continuously for five minutes between conductors and between any conductor and the sheath or armor.

275. Special Crossing Construction

(*a*) *Short Spans.*—In cases where the crossover span is constructed of such a height that its length is less than the distance between either point of support of its lowest conductor and the highest conductor of the line crossed, the requirements for conductor sags and for size and type of conductors in section 24 are waived, provided that a permanently grounded guard arm is installed at each crossover support in such a manner as to prevent conductors, which break in either adjacent span, from swinging back into the conductors of the span crossed over.

This character of construction is facilitated where the span crossed over is at a minimum elevation above ground level, and where the crossover supports can be placed quite near together.

(*b*) *Cradles.*—Cradles are not recommended. It is less expensive and better to build the supply line strong enough to withstand extreme conditions than to build a cradle of sufficient strength to catch and hold the supply line if it falls.

SEC. 28. STRENGTH AND OTHER REQUIREMENTS FOR SIGNAL LINES AT CROSSINGS AND ALONE

280. General Requirements

(*a*) *Conditions Determining Grade.*—Signal lines crossing over railways, except in the cases mentioned in rule 235 (*b*), (*c*), (*d*), (*e*), are classed as grade D and shall have construction in accordance with the following requirements. Signal lines crossing over minor tracks (as described in rule 235 *b*) shall conform to the requirements for grade E.

Where also crossing over supply lines (or signal lines having the character of supply lines) in the same span, the construction required shall comply either with grade D, grade E, or grade A or B, according to the voltage of the supply line. (See sec. 23.)

Signal lines crossing over the supply lines covered in rule 234 (*c*), and also crossing over railways in the same span, shall comply with grade D or E requirements except that grade C requirements apply to conductor sizes and sags for spans exceeding 150 feet.

The requirements for signal lines crossing over or conflicting with supply lines only are specified in rule 287, and for signal lines crossing over trolley contact conductors in rule 286.

(*b*) *Transverse and Longitudinal Strength.*—The paragraphs which specify the transverse and longitudinal requirements relate to grade D construction unless otherwise stated. For grade E the transverse and longitudinal strength shall be not less than two-thirds of that required for grade D.

(*c*) *Preliminary Assumptions.*—In the calculation of all stresses no allowance shall be made for deformation, deflection, or displacement of any part of the supporting structures.

(*d*) *Three Loading Districts.*—Three districts have been outlined in which heavy, medium, and light loading, respectively, are considered to be justified by weather reports as to wind and ice and by local experience of the utilities using overhead lines. A map of the United States showing the territory falling into each class of loading is given in Appendix A.

The localities in the different districts are classified according to the relative prevalence of high wind velocity and thickness of ice which accumulates on the wires, light loading being in general for places where little if any ice ever accumulates on wires. If high wind velocities are frequent in a given place, the loading for that place may be classed as heavy even though ice does not accumulate to any greater extent than at some other place having less severe winds which has been classed as a medium loading district.

(*e*) *Modification of Loading Areas.*—In the absence of any action by the administrative authority fixing the loadings for any given jurisdiction, the classification of loadings shown on the map in Appendix A shall be considered to apply unless the party or parties responsible for the lines concerned assume some modification of the same, based upon local experience or weather records, or both. These modifications shall be subject to review by the administrative authority.

In case a State is redistricted by State administrative authority, so as to meet local weather conditions better than the map of Appendix A, a grade of loading above heavy may be used, if necessary to meet such local conditions.

(*f*) *Inspection.*—All parts of the supporting structures of the crossing span shall be examined annually by the owner and all defective parts shall be promptly restored to a safe condition.

281. Transverse and Longitudinal Strength

(*a*) *Transverse Guying.*—The poles supporting the crossing span shall be side guyed or braced to withstand the transverse load put upon them in accordance with the conditions specified in (1), (2), or (3) below, except as provided in (*c*). The guys shall be considered as taking, in the direction in which they act, the horizontal component of the entire load, the poles, acting as struts, resisting the vertical component. The calculated stresses in the guys shall not exceed one-half of the ultimate strength of the material.

(1) *Heavy Transverse Loading.*—In regions of heavy loading the assumed horizontal wind pressure at right angles to the direction of the line upon the poles and conductors shall be taken as 8 pounds per square foot of projected area on cylindrical surfaces. The pressure shall be computed upon the poles without ice covering, while the conductors shall be assumed to be covered with a layer of ice one-half inch in radial thickness. In computing the transverse pressure on conductors the actual number of conductors shall be used up to 10. For larger numbers of wires only two-thirds of the total number shall be counted with a minimum of 10.

In calculating transverse load a cable with its supporting messenger with the ice covering shall be figured at their full value.

(2) *Medium Transverse Loading.*—In regions of medium loading the transverse wind pressure shall be taken as two-thirds that for heavy loading.

(3) *Light Transverse Loading.*—In regions of light loading the transverse wind pressure shall be taken as four-ninths that for heavy loading.

(*b*) *Longitudinal Guying.*—The poles supporting the crossing span shall be head guyed away from the crossing so as to withstand the load specified in (1), (2), or (3) below, except as provided in (*c*). The guys shall be considered as taking, in the direction in which they act, the horizontal component of the entire load, the poles, acting as struts, resisting the vertical component. The calculated stresses in the guys shall not exceed the ultimate strength of the material.

(1) *Heavy Longitudinal Loading.*—In regions of heavy loading the longitudinal load shall be assumed equivalent to an unbalanced pull in the direction of the crossing of all conductors or wires supported, the pull of each conductor or wire being taken as one-half its ultimate strength. In any case where the total pull exceeds 10 000 pounds the load shall be taken as 10 000 pounds plus one-quarter of the excess above 10 000 pounds.

For head-guying, cables are not included in the count of wires since the messenger serves as a head guy.

(2) *Medium Longitudinal Loading.*—In regions of medium loading the longitudinal load shall be taken as two-thirds that for heavy loading.

(3) *Light Longitudinal Loading.*—In regions of light loading the longitudinal load shall be taken as four-ninths that for heavy loading.

(*c*) *Omission of Guys.*—If a pole is of such strength that it will not be stressed by the specified transverse loading beyond one-fourth its ultimate strength when installed, side guys may be omitted. If the specified longitudinal loading on such a pole will not stress it initially beyond one-half its ultimate strength and there are not more than two wires in the crossing span, head guys may also be omitted.

(1) Where an overhead crossing which makes an angle with the tracks of less than 45° involves at either crossing pole an angle in the pole line, the side guy within the angle may be omitted.

(2) Where a signal line paralleling a railroad track on the right of way of the railroad crosses a spur or stubtrack without any change in general direction of line, the transverse strength requirements for grade E construction may be met without the use of side guys, providing the pole is not stressed beyond one-half its ultimate strength, and no requirements for longitudinal strength are made if conductor tensions are balanced. Where conductor tensions are not balanced, due to a small angle in the line at one or both poles or to dead-ending any of the wires, guys or braces shall be installed capable of withstanding such unbalanced tensions.

282. Relation of Crossing Span to Line

(a) *Span Length.*—Poles should, where practicable, be so located that crossing and adjacent spans are in a straight line and free from exposure to overhanging or closely adjacent trees or inflammable material or structures. (See rule 211 for requirements as to location of poles.)

The crossing span shall be as short as practicable and, in general, shall not be longer than the normal span of the line. No crossing span shall exceed 125 feet in length if this can be avoided.

(b) *Grading or Vertical Displacement of Crossing Span.*—The vertical distance from the top cross arm of a crossing pole to a straight line connecting the top cross arms of the next adjacent poles on either side of this crossing pole shall not exceed the values given below:

Average length of span in feet:	Allowable vertical distance in feet
Less than 100	4
100 to 130	5
Exceeding 130	6

(c) *Guying in Special Cases.*—Where on account of physical conditions it is impracticable to guy or brace the crossing poles as specified in rule 281, the requirements there given may be met by head-guying and side-guying the line as near as practicable to the crossing, but at a distance not exceeding 500 feet from the nearest crossing pole, provided that the line is approximately straight and that a cable of strength equivalent to that of the head guy is run between the two guyed poles, being attached to the guyed poles at the point at which the head guys are attached, this cable being securely attached to every pole between the guyed poles.

Where the poles supporting the crossing span are not in line with the poles in the adjoining spans, additional guying shall be placed to take care of the increased stress.

283. Minimum Sizes and Construction Details

(a) *Size of Pole and Setting.*—Wood poles supporting the crossing span shall be of selected timber, sound and reasonably straight. Poles shall have dimensions not smaller than the values given in the tables of Appendix B-4 when carrying the numbers of wires there designated.

Grade D.—The minimum dimensions given in the tables of Appendix B-4 correspond to poles designated by the wire-owning companies as class C, where not more than 20 wires are carried; class B, where 21 to 40 wires are carried; class A, where more than 40 wires are carried.

Grade E.—The minimum dimensions given in the tables of Appendix B-4 correspond to poles designated by the wire-owning companies as class C, where not more than 40 wires are carried; class B, where more than 40 wires are carried.

Poles shall be set to such a depth and in such a manner and back filling shall be tamped so thoroughly that the applied load will break the pole before the butt is pulled loose in its setting.

A table of recommended depths of setting is given in Appendix B-4.

(b) *Cross Arms.*—Wood cross arms supporting the crossing span shall be of yellow pine, fir, or other suitable timber and shall have a minimum section of 2¾ by 3¾ inches for 6-foot or shorter arms and 3 by 4 inches for arms longer than 6 feet. Galvanized or painted iron or steel cross arms of equal strength may be used.

In rural districts in arid regions where the practice has been established of using 2¾ by 3¾ inch arms in 8 and 10 pin lengths, this practice may be continued where conductors are not larger than No. 10.

Cross arms and insulators shall be double on the crossing poles. The cross arms shall be held together with properly fitted spacing blocks or bolts placed immediately adjoining the outside pins and shall not support more than 10 conductors. Brackets or racks may be used only if used in duplicate or otherwise designed so as to afford two points of support for each conductor, except that for supporting twisted-pair wires, a single metal bracket, designed to safely withstand the full dead-end pull of the wires, may be used.

(*c*) *Pins, Insulators, and Tie Wires.*—Insulator pins shall be of steel, wrought iron, malleable cast iron, or locust or equivalent wood. Steel or iron pins shall have diameter of shank not less than one-half inch. Wood pins shall be sound and straight grained with a diameter of shank not less than 1¼ inches. Insulator pins shall have strength sufficient to withstand the loads to which they may be subjected.

Each insulator shall be of such pattern, design, and material that when mounted it will withstand, without injury and without being pulled off the pin, the ultimate strength of the conductor attached to the insulator. The conductors shall be securely tied to each supporting insulator.

(*d*) *Conductors.*—Conductors shall be of hard-drawn copper, copper-covered steel, galvanized steel, or other hard-drawn corrosion-resisting metal, provided, however, that galvanized steel shall not be used in localities where excessive corrosion would result.

If spans in excess of 150 feet are necessary, the size of conductors specified or the sags shall be correspondingly increased. (See rule 282 *a*.)

Conductors of material other than the above shall be of such size and so erected as to have a mechanical strength not less than that of the sizes of copper conductors given below.

Twisted-pair wires without a supporting messenger shall in no case be used for grade D in spans longer than 100 feet, nor for grade E in spans longer than 125 feet, and shall be eliminated as far as practicable. Each wire of a twisted pair not supported by a messenger shall be tinned hard-drawn copper not smaller than No. 14, or tinned copper-covered steel not smaller than No. 17.

The minimum allowable sizes for conductors of the crossing span shall be as follows:

TABLE 11.—Minimum Wire Sizes for Grade D

Conductor	Spans 125 feet or less	Spans exceeding 125 feet up to 150 feet
Hard-drawn copper	No. 10 A. W. G	No. 9 A. W. G.
Galvanized steel	No. 10 Stl. W. G	No. 8 Stl. W. G.
Galvanized steel in rural districts of arid regions.	No. 12 Stl. W. G	No. 10 Stl. W. G.

TABLE 12.—Minimum Wire Sizes for Grade E

Conductor	Spans 125 feet or less	Spans exceeding 125 feet up to 150 feet
Hard-drawn copper in heavy loading districts.	No. 10 A. W. G	No. 10 A. W. G.
Hard-drawn copper in medium and light loading districts.	No. 12 A. W. G	No. 10 A. W. G.
Galvanized steel	No. 12 Stl. W. G	No. 10 Stl. W. G.

Minimum Wire Sizes for Grade C.—Signal conductors which are required to comply with grade C construction may be smaller than grade C supply conductors, but must not be smaller nor have less sags than for grade D construction for spans up to 150 feet; for spans exceeding 150 feet the requirements for supply conductors must be met.

Conductors of the crossing span shall be strung with sags not less than shown in the following table:

TABLE 13.—Sags of Hard-Drawn Bare Copper Wire or Steel

Length of span	Sag in inches		
	At 20 °F	At 60 °F	At 100 °F
80 feet	2.5	4.5	8.5
90 feet	3.5	5.5	10
100 feet	4.5	7	12
110 feet	5.5	8.5	14
120 feet	6.5	10	16
130 feet	7.5	12	19
140 feet	9.5	15	22
150 feet	11.5	18	25

(e) *Guys.*—Guy anchors shall, where possible, be located so that the horizontal distance from the ground line of the pole to the guy or guy rod will be not less than the height above ground of the attachment of the guy to the poles for head guys, and not less than one-third that height for side guys. The guys shall be attached as near to the center of the load as practicable. The guys and anchors shall be maintained so that the guys are kept taut and serve the purpose for which they are intended.

(f) *Messengers.*—The following table gives the minimum sizes of galvanized-steel-strand messenger cable to be used for supporting different sizes of conductor cable:

TABLE 14.—Minimum Sizes of Messenger Cable

Size of conductor cable in weight per foot	Messenger cable (nominal ultimate tensile strength)
	Pounds
Less than 2.25 pounds	6 000
2.25 to 5 pounds	10 000
Exceeding 5 and less than 8 pounds	16 000

For spans exceeding 150 feet or for heavier cables a proportionately larger messenger cable or other proportionately stronger means of support shall be used.

Multiple-wire cables and their messengers shall be suspended with a normal sag at 60° F so that when they are subjected to the loading prescribed in rule 281 the tension in the messenger cable will not exceed the following values:

Nominal ultimate tensile strength of messenger cable	Safe working tension of messenger cable
Pounds	Pounds
6 000	3500
10 000	5900
16 000	9500

284. Signal-Line Clearances

(*a*) *Clearances from Ground or Rails.*—The clear space between the lowest signal conductor, guy, or messenger and the heads of rails shall, at 60° F with no wind, be, in general, not less than 27 feet.

When the signal conductors are paralleled on the same highway by a trolley contact conductor at a lower level, the clearance of the signal conductors from the rail may be reduced to 25 feet.

When signal conductors cross tracks not carrying traffic which involves brakemen riding on top of standard freight cars, the above clearance may be reduced to 18 feet.

When spans exceed 150 feet in length, additional clearance must be provided as given by rule 220 (*b*).

(*b*) *Clearances from Other Wires.*—The clear space between the lowest signal conductor, guy or messenger and the highest wire of a similar nature paralleling the track, shall be not less than 2 feet where the sum of the distances from the point of intersection to the nearer supporting structure of each span is 100 feet or less. Where the sum of these distances exceeds 100 feet and for crossings over supply wires, the requirements of rule 220 (*c*) and (*d*) must be met.

The vertical clearance between conductors supported on the same pole or structure and at different levels shall in no case be less than 12 inches and preferably 24 inches. (See also rule 223.)

(*c*) *Pole Clearances.*—Unless physical conditions or municipal requirements prevent, the side clearance of poles shall be not less than 12 feet from the nearest track rail, except at sidings where clearance of not less than 7 feet may be allowed. Where conductors of one pole line cross over or under conductors of a second line, there shall, if practicable, be not less than 3 feet clearance between the conductors of the first line and any pole or tower of the second line, unless the conductors are attached thereto.

285. Crossings of Signal Lines Beneath Railways

(*a*) *Underground.*—Underground signal lines crossing railways shall conform to the requirements of sections 20 and 29 and particularly of rules 290 and 295. Manholes, pull boxes, and terminals shall be located away from the road bed (preferably outside the fenced right of way of the railway). Conductors and cables carried underground under railways shall be placed in suitable ducts conforming to the requirements of section 29.

(*b*) *Under Bridges.*—Overhead signal lines passing beneath bridges over which railways pass shall conform to the general requirements of section 20, to the requirements for grade of construction of section 23, to the requirements for conductor clearances and separations of section 22, and to the special requirements for supports and wiring arrangements of section 21.

286. Signal Lines Crossing Over Trolley Contact Conductors (where grade D or E is not required)

(*a*) *Not Exceeding 750 Volts.*—Signal lines, except twisted-pair conductors and fire-alarm conductors, carried over trolley contact conductors of not more than 750 volts shall have conductor sizes not less than No. 12 hard-drawn copper or steel in spans less than 100 feet, No. 10 in spans of 100 to 125 feet, No. 9 in spans up to 150 feet, all with sags not less than given in Table 13 for grade D. For spans longer than 150 feet the requirements of rule 246 for conductor sizes and of Appendix A for sags of grade C supply lines shall be complied with.

Twisted-pair conductors, unsupported by messengers, shall not be used in spans exceeding 100 feet, if carried over trolley contact conductors unless each wire is hard-drawn copper not less than No. 14 or copper-covered steel not less than No. 17.

The clearance of signal lines above contact conductors crossed over shall be in accordance with the values given in rule 220 (*c*) and (*d*).

(*b*) *Exceeding 750 Volts.*—For signal lines carried over trolley contact conductors of more than 750 volts to ground, see rule 234.

Twisted-pair conductors may be used under the restrictions given in (*a*) above, but if in A or B construction they shall have sags not less than those required by Appendix A for No. 8 hard-drawn copper, and where supported by a messenger the messenger shall have the sags required in rule 283 (*f*). Where supply-line voltage exceeds 7500 volts the twisted pair shall always be supported by a messenger.

The clearances of signal lines above the contact conductors crossed over shall be in accordance with the values given in the table of rule 220 (*c*).

287. Signal Lines Crossing Over or Conflicting with Supply Lines of More than 750 Volts (not recommended except over trolley feeders)

(*a*) *Strength of Construction.*—Overhead signal lines crossing over supply lines under the circumstances noted in rule 234 shall comply with the construction requirements of grade A, B, or C as required in that rule. (See rule 289 for signal lines used in the operation of supply lines.)

(*b*) *Compliance with Other Rules.*—Where signal lines crossing over supply lines are required to comply with grade A, B, or C construction, they shall comply as to conductor sizes, materials, and sags, and as to materials and strength of supporting structures and attachments with section 24; as to separation and clearances of conductors and wires of the signal lines themselves with the requirements of section 22; as to guys and their insulators with the requirements of rules 212 and 213, and in general with the requirements of sections 20 and 21.

(*c*) *Where Concerned Also with Railways.*—Where the signal lines referred to in (*a*) above are required to comply with grade C construction and also cross over railways under circumstances calling for compliance with grade D or E construction, grade D or E shall be met in all respects except as to conductor sizes and sags, which shall comply with grade C. For spans up to 150 feet these are the same as for grade D, rule 283 (*d*). For spans exceeding 150 feet see rule 246 (*b*) and Appendix A.

(*d*) *Pole Clearance.*—The pole or tower structures of each line concerned in the crossover shall have clearances from the conductors of the other line as required by rule 221 or 227, whichever applies.

(*e*) *Wire Clearance above Supply Lines.*—The clear space between the lowest overhead signal line conductor (or guy, messenger, or span wire) crossing over any supply line conductor or guy, span, or messenger wire [10] shall not be less than given below, at 60° F with no wind, where the upper conductor or wire has fixed supports and the sum of the distances from the point of intersection to the nearest supporting structure of each span does not exceed 100 feet.

	Feet
Signal lines:	
Above supply conductors of less than 7500 volts	4
Above supply conductors 7500 to 50 000 volts	6
Above supply service conductors (not exceeding 750 volts)	2
Above supply guy, messenger, and span wires	2
Guy, span, and messenger wires:	
Above supply conductors of less than 750 volts	2
Above supply conductors 750 to 7500 volts	4
Above supply conductors 7500 to 50 000 volts	4

(*f*) *Clearance Increases.*—Clearance increases for long spans and high voltages are given in rule 220 (*d*).

(*g*) *Falling Trees.*—The crossing span and the next adjoining span, so far as practicable, shall be kept free from overhanging or decayed trees which might fall into the line. (See also rule 209.)

(*h*) *Special Longitudinal Requirements.*—For special requirements for longitudinal strength of crossover supports of signal lines crossing over supply lines, where compliance with grade A or B is required for the signal lines, see rule 249.

(*i*) *Special Short-Span Crossovers.*—For special short-span crossing construction, see rule 275.

(*j*) *Guys.*—Guys may be used to meet the strength requirements of section 24 and where used they and their insulators and guards shall conform to rules 212 and 213.

(*k*) *Signal Lines Conflicting with Supply Lines.*—Where signal lines are at higher levels and conflict with supply lines the requirements of (*a*) and (*b*) above apply in general to the con-

---

[10] Except for crossings between conductors and guy, messenger or span wires on the same pole, for which see rule 221.

flicting signal lines just as they apply where the signal lines cross over the same supply lines.

Clearances from the poles and conductors of a second line are given in rule 227.

Requirements for guys are given in rule 212.

288. Signal Lines Alone (or Concerned Only with Other Signal Lines)

(*a*) *Fire-Alarm Lines.*—Conductors used for fire-alarm circuits shall comply with the requirements of rule 283 (*d*) for sizes and sags in spans up to 150 feet. For spans exceeding 150 feet they shall have grade C sizes as given in rule 246 (*b*) and sags not smaller than listed for grade C in Appendix A.

Where carried at higher levels than supply conductors in crossings, conflicts, or common use of poles, they shall comply with grade A, B, or C construction requirements according to rule 234.

(*b*) *Other Signal Lines.*—Conductors for signal lines other than fire-alarm lines unless crossing at higher levels or conflicting with, or on the same poles above supply (or trolley) lines, need not comply with any requirements as to size, material, or sag.

(*c*) *Supporting Structures for Signal Lines.*—The poles used for other signal lines, unless exposed to supply (or trolley) lines by crossing above, conflicting with, or being carried above the supply lines on the same poles, need not comply with any requirements as to strength and material except that poles and cross arms shall be of such initial size, and so guyed or braced where necessary as to safely withstand the vertical loads to which they may be subjected, including linemen working on them.

In other respects all signal-line supports shall comply with the general requirements of sections 20 and 21 covering traffic guards, pole clearances, guys, and other matters.

(*d*) *Clearances above Ground* (See also rule 220 *a* and *b*).—Signal conductors alone and their guys, span wires, and messengers shall have clearances above streets, highways, alleys, or generally accessible spaces across or along (and above) which the former pass, not less than the following at 60° F, with no wind, when the spans do not exceed 150 feet.

	Feet
Signal lines, or guy, span, or messenger wires:	
Above streets and other traveled roadways	18
Along roads in rural districts	15
Crossing above spaces or ways accessible only to pedestrians (if less than 150 volts—10 feet)	12
Above roadways to residence garages	10

The clearances do not apply to guys not carried over roadways, or to guys along one side of a street or alley, unless over driveways. For guys on private right of way, or parallel to sidewalk curbs, when not passing over pathways or roadways, no clearance is required; and if passing over only pathways the clearance may be reduced to 8 feet.

For signal-line spans exceeding 150 feet these clearances shall be increased at the rate of 1 inch for each 10 feet excess.

(*e*) *Clearances from Other Signal Lines* (See also rule 220 *c* and *d*).—Signal conductors and their guy, span, or messenger lines concerned in crossings, conflicts, or common use of poles with other signal lines only, shall have a minimum of 2 feet clearance from those of other lines.

Except for fire-alarm lines this may be reduced where desired, unless one set of conductors is for public use and the other is used in the operation of supply lines.

(*f*) *Grounding, Isolation, or Protection.*—Signal lines, including fire-alarm lines, if at any point in their course exposed by supply (or trolley) lines of more than 400 volts to ground, shall be protected at each station for public use by one of the methods specified in Part 3, section 39. These lines shall elsewhere be isolated by elevation or otherwise guarded so as to be inaccessible to the public.

Signal lines used in the operation of supply lines shall be at all points isolated by elevation or otherwise guarded so as to be inaccessible to the public.

Metal-sheathed cables and messengers shall be isolated or grounded in conformity with the general requirements of section 20.

289. Signal Lines Used Exclusively in the Operation of Supply Lines

(a) *Under Other Lines.*—Such signal lines when (1) crossed over by, or (2) having conflicting with them, or (3) on common poles and below high-voltage direct-current trolley circuits or other supply lines in the operation of which they are used, may be considered and run as ordinary signal lines if (1) the signal lines do not cross over or conflict with, and are not on common poles, with and higher than other lines or equipment, and (2) the signal lines and connected equipment are adequately guarded and accessible only to authorized persons and (3) the precautions of sections 39 and 54 have been taken.

The supply lines concerned above are not required by the conditions described to comply with the requirements of sections 25 and 27 as to strength of construction, but the conductors shall be not smaller than permitted by rule 246 (*b*).

(*b*) *Over Other Lines.*—Such signal lines, if crossing over, conflicting with, or higher on common poles with other lines or equipment shall comply with all the requirements for the highest voltage supply lines of not more than 7500 volts with which the signal lines may come in contact, except as to wire sizes for grade C for which see rule 283 (*d*). If, however, the signal lines are protected by fuseless lightning arresters, drainage coils, or other suitable protective devices to prevent the signal line voltage from normally exceeding 400 volts to ground, they may be run as ordinary signal lines. The method used shall be consistently adhered to throughout the extent of the signal system.

SEC. 29. UNDERGROUND LINES

290. Location and Accessibility of Conduits and Manholes

(*a*) *General Locations.*—Underground systems of electrical conductors should be so located as to be subject to the least practicable amount of disturbances. When being designed and installed, care should be exercised to avoid catch basins, street railway tracks, gas pipes, or other underground structures.

(*b*) *Ducts.*—To facilitate installing and withdrawing cables and conductors, the ducts between adjacent manholes or other outlets should be installed in straight lines, except when it is necessary to install curves, in which case they should be of the greatest practicable radius, and the spacing between adjacent manholes should be correspondingly reduced.

(*c*) *Manholes.*—Manholes shall, where practicable, be so located as to provide convenient access and, if possible, so that the least horizontal distance from any rail of a railroad track to the nearest edge of a manhole opening is not less than 3 feet.

291. Grading of Ducts

Manholes or handholes should be so located and ducts so graded that drainage of ducts will always be toward manholes or handholes. To insure satisfactory drainage, the ducts shall be so installed as to provide, where practicable, a grade of not less than 3 inches in 100 feet of length.

292. Mechanical Details of Manholes

(*a*) *Minimum Strength.*—The mechanical design and construction of manholes and handholes shall be such as to provide sufficient strength to safely sustain with a suitable margin of safety the mechanical loads which reasonably may be expected upon them.

(*b*) *Entrance.*—The entrance to all manholes shall be not less than 24 inches minimum diameter. Round openings are recommended.

(*c*) *Dimensions*.—Manholes should be so constructed, when practicable, that the least inside horizontal dimensions will be not less than 3 feet 6 inches and should be so arranged as to maintain, if practicable, a clear working space not less than 3 feet horizontally and 6 feet vertically, except that where the opening is within 1 foot on each side of the full size of the manhole the depth may be less.

(*d*) *Drainage and Ventilation*.—Where surface or ground water is liable to enter manholes containing supply conductors, these shall be so arranged, if practicable, as to provide permanent drainage.

Where drainage is into sewers, suitable traps shall be arranged to prevent entrance of sewer gas into manholes.

Manholes shall have adequate ventilation to open air where this is practicable and can be arranged without permitting entrance into the manhole of surface water, and such ventilation shall always be provided where any opening exists from such chambers into subways entered by the public, as with some subway conduit systems.

293. Manhole Covers and Guards

(*a*) *Covers*.—Manholes and handholes, while not being worked in, shall be securely closed by covers of sufficient strength to sustain such mechanical loads as may reasonably be expected to be imposed upon them, and the arrangement shall be such that a tool or appliance is required for their opening or removal.

(*b*) *Barriers or Guards*.—Manhole openings shall be so arranged that when they are uncovered barriers or other suitable guards may be placed to effectively protect the opening.

294. Material, Size, and Finish of Ducts

Ducts used in underground systems of distribution for electrical supply and signal conductors shall be of such material, size, mechanical strength, and finish as to facilitate the installation and maintenance of conductors or cables.

295. Installation of Conduits

(a) *Protection.*—Ducts should be suitably reinforced or be laid on suitable foundations of sufficient mechanical strength where necessary to protect them from settling, and should be protected by concrete or other covering where necessary to prevent their disturbance by workmen when digging, or by other causes. The distance between the top of the conduit covering and the pavement surface or other surfaces under which the duct run is constructed shall be sufficient to protect the conduit from injury, and shall generally be at least 30 inches to the underside of track rails beneath which conduit passes.

(b) *Smooth Surfaces.*—Ducts shall have clear bores and be freed from burrs before laying. They shall be laid in line in such manner as to prevent inside shoulders at joints.

(c) *Termination in Manhole.*—Iron-pipe conduit terminating in manholes, handholes, or other permanent openings of underground systems shall be provided with an effective bushing or other smooth outlet.

(d) *Clearances.*—Duct runs should provide as great a clearance from other underground structures as practicable, and particularly from gas lines paralleling them.

(e) *Walls between Supply and Signal Conduits.*—Conduits for underground conduit systems to be occupied by signal conductors for public use should, where practicable, be separated from underground conduit systems for supply conductors by not less than 3 inches of concrete or its equivalent.

Cable extensions may, however, be made to existing interconnected or jointly owned and jointly occupied duct systems used in common by municipalities, signal and power companies, with less effective separations than above specified.

(*f*) *Supply and Signal Conduits in Manholes.*—Where signal conductors for public use and supply conductors occupy ducts terminating in the same manhole, the two classes of duct should be separated as widely as practicable; and, where practicable, enter the manhole at opposite sides, so that cables can be racked along side walls with a minimum of crosses between the two classes of conductors.

(*g*) *Joints.*—Joints in duct runs shall be made mechanically secure to maintain individual ducts in alignment.

(*h*) *Openings into Manholes.*—Duct openings into manholes or handholes should, where practicable, have a clearance above the floor or below the roof line of not less than 6 inches.

(*i*) *Laterals.*—Ducts of laterals supplying service to buildings, where gas or water is liable to enter through them, should be effectively plugged or cemented by the use of asphaltum, pitch, or other suitable means.

(*j*) *Dissipation of heat.*—Conduits designed to carry supply cables of large current capacity should be arranged, where practicable, so that no ducts necessarily dissipate heat solely through adjacent ducts.

296. Location and Identification of Conductors

(*a*) *Separation of Supply and Signal Systems.*—Underground systems of electrical supply conductors and of signal conductors for public use should, in general, be maintained in separate conduits and manholes.

Cable extensions to existing interconnected or jointly owned and jointly occupied duct systems used in common by municipalities, signal companies, and power companies are exempted from the above.

(*b*) *Separation in Same Manhole.*—When signal conductors for public use and electrical supply conductors occupy the same manholes, they should be maintained at opposite sides of the manhole; and where supply cables are of large current capacity all cables should be specially protected against injury by arcing. When it is necessary that the signal and supply cables cross in any manhole, a spacing of at least 1 foot shall be maintained and special mechanical protection provided against abrasion or injury by arcs.

(c) *Identification.*—Cables shall be permanently identified by tags or otherwise at each manhole, handhole, or other permanent opening of the underground system, except where their position, in conjunction with diagrams supplied to workmen, gives sufficient identification.

(d) *Accessibility.*—Cables in manholes shall be reasonably accessible from the clear working space at all times. When cables cross by or over other cables, sufficient clearance shall be provided between them to permit reasonable access to any cable for inspection and repair and to prevent abrasion.

Joints made in, or branches made from, underground cables should be reasonably accessible at all times and should be in manholes or handholes, and as seldom as possible in the ducts themselves.

(e) *Clearance in Manholes.*—Each cable, where practicable, shall maintain a vertical clearance above the floor of any manhole of not less than 6 inches.

297. Mechanical Protection, Support, and Guarding of Live Parts

(a) *Cable Sheath.*—Cables, unless rubber insulated, shall be provided with a water-tight metal sheath or other waterproof covering over their insulating coverings, except when used as ground connections or neutrals. Where closely grouped lead-covered cables include cables operating at more than 7500 volts, they should have suitable fire-resistive coverings to prevent damage from arcing.

Such protection is also frequently advisable where all voltages are less than 7500, especially where some of the cables are of large current capacity.

(b) *Guarding of Live Parts.*—Protective, control, or other apparatus on supply lines where installed and maintained in manholes and handholes shall have live parts inclosed in suitable cases. The metal sheathing of all conductors or cables shall be made mechanically and electrically continuous with the metal cases of protective, control, or other apparatus.

Joints or terminals of conductors or cables of underground systems of electrical supply shall be so arranged that there are no bare ungrounded current-carrying metal parts exposed to accidental contact within manholes or handholes.

(*c*) *Supports*.—Mechanical supports shall be provided for all cables at each manhole, handhole, or other permanent opening.

(*d*) *Underground Risers*.—Conductors or cables from underground systems which connect to overhead systems shall be mechanically protected by installing them in grounded metal conduit or, in the case of signal cable or metal-sheathed cable, in other substantial conduit, and shall terminate in suitable potheads or similar devices of approved design or construction; the open supply wiring connecting to the underground system shall begin not less than 10 feet above the ground surface or platform accessible to the public.

298. Spacing of Cables

(*a*) *Different Voltages*.—Cables shall be so arranged and supported in ducts and manholes that those of higher operating voltages are separated from those of lower voltages as far as practicable.

(*b*) *Different Systems*.—Cables belonging to different systems (particularly supply distribution and signal systems) shall not be run in the same duct.

299. Multiple Connections

When transformers, regulators, or other similar apparatus operate in multiple, special tags or other suitable means shall be used to indicate that fact.

APPENDIXES TO PART 2

APPENDIX A. LOADING DATA, MECHANICAL CHARACTERISTICS, AND RECOMMENDED NORMAL SAGS OF OVERHEAD LINE CONDUCTORS

1. Recommended Sags, with Corresponding Tensions and Stresses of Copper Line Conductors

While the following sags are those generally recommended, circumstances will sometimes call for modifications. For instance, where many large conductors are carried by a pole line, greater sags than those listed for the large conductors will sometimes be advisable, to reduce the stresses on poles at turns and dead ends, and to permit smaller longitudinal guying at crossovers where such guying is called for by the rules. (See rule 249.)

The figures given for the sags and tensions have been rounded off to the nearest value which can be readily measured by methods and instruments in practical use for this purpose. Simple and fairly accurate methods for measuring sags will be given in a future supplementary volume.

TABLE 15.—Sags for Hard and Medium-Drawn Bare Copper Wire for Different Span Lengths

(At 30, 60, and 90° F—wires without load)

HEAVY LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—								
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.
		°F	In.	In.	In.	In.	In.	In.	In.	In.	In.
8	C.......	30	8	11	22	......	......	......	......	......	......
		60	12	18	27	......	......	......	......	......	......
		90	16	22	32	......	......	......	......	......	......
6	A.......	30	8	11	22	......	......	......	......	......	......
		60	12	18	27	......	......	......	......	......	......
		90	16	22	32	......	......	......	......	......	......
6	B.......	30	6	10.5	16	......	......	......	......	......	......
		60	10	15	22	......	......	......	......	......	......
		90	14	19.5	27	......	......	......	......	......	......
6	C.......	30	6	10.5	16	28	......	......	......	......	......
		60	10	15	22	33	......	......	......	......	......
		90	14	19.5	27	39	......	......	......	......	......

TABLE 15—Continued

HEAVY LOADING DISTRICTS—Continued

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.
		°F	In.	In.	In.	In.	In.	In.	In.	In.	In.
4	All......	30	6	10.5	16	22	32	64	109	......	......
		60	10	15	21	28	38	71	115	......	......
		90	14	19.5	26.5	34	45	77	120	......	......
2	All......	30	6	10.5	13	16	18.5	35	59	129	218
		60	10	15	18	21	24	44	68	137	226
		90	14	19.5	23.5	28	31	51	75	144	234
1	All......	30	6	10.5	13	16	18.5	32	51	113	195
		60	10	15	18	21	24	40	59	120	203
		90	14	19.5	23.5	28	31	47	67	130	212
0	All......	30	6	10.5	13	16	18.5	31	45	100	170
		60	10	15	18	21	24	38	55	110	180
		90	14	19.5	23.5	28	31	46	63	120	190
00	All......	30	6	10.5	13	16	18.5	29	42	92	157
		60	10	15	18	21	24	36	50	102	168
		90	14	19.5	23.5	28	31	44	58	111	179
0000	All......	30	6	10.5	13	16	18.5	26	34	73	118
		60	10	15	18	21	24	32	42	84	132
		90	14	19.5	23.5	28	31	40	50	94	142

MEDIUM LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft.	1000 ft.
		°F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
8	C....	30	5.5	8.5	13	......	......	......	.....	.....	.....	.....	.....
		60	8	12	18	......	......	......	.....	.....	.....	.....	.....
		90	12	17	23.5	......	......	......	.....	.....	.....	.....	.....
6	All...	30	5.5	8.5	13	18.5	......	......	.....	.....	.....	.....	.....
		60	8	12	18	24	......	......	.....	.....	.....	.....	.....
		90	12	17	23.5	30	......	......	.....	.....	.....	.....	.....
4	All...	30	5.5	8.5	13	18.5	25	35	61	134	.....	.....	.....
		60	8	12	18	24	32	42	69	141	.....	.....	.....
		90	12	17	23.5	30	39	50	77	149	.....	.....	.....
2	All...	30	5.5	8.5	13	16.5	20	29	41	78	139	313	.....
		60	8	12	18	22	26	36	50	88	150	324	.....
		90	12	17	23.5	28	33	44	58	100	161	334	.....
1	All...	30	5.5	8.5	13	15.5	18.5	24.5	32	62	111	275	.....
		60	8	12	18	21	24	31	40	72	124	286	.....
		90	12	17	23.5	28	31	39	48	83	135	298	.....

TABLE 15—Continued

MEDIUM LOADING DISTRICTS—Continued

Size A.W.G. No.	Grade of construction	Temperature	Sags for span length of—										
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft.	1000 ft.
		°F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
0	All...	30	5.5	8.5	13	15.5	18	23.5	29	54	95	218	.....
		60	8	12	18	20.5	23	29	37	64	108	239	.....
		90	12	17	23.5	27.5	19.5	36	44	74	120	253	.....
00	All...	30	5.5	8.5	13	15	17	21.5	27	47	80	177	396
		60	8	12	18	20	22	27	33	55	92	192	415
		90	12	17	23.5	26	28	34	41	65	104	208	429
0000	All...	30	5.5	8.5	13	14.5	16	19	23	41	66	140	304
		60	8	12	18	19	21	24	27	48	76	154	323
		90	12	17	23.5	25	27	30	33	57	88	171	340

LIGHT LOADING DISTRICTS

Size A.W.G. No.	Grade of construction	Temperature	100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft.	1000 ft.
		°F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
8	C....	30	4.5	6.5	9.5	15	.....	.....	.....	.....	.....	.....	.....
		60	6	9	13	20	.....	.....	.....	.....	.....	.....	.....
		90	9	13	18	26	.....	.....	.....	.....	.....	.....	.....
6	All...	30	4.5	6.5	9.5	13.5	18.5	.....	.....	.....	.....	.....	.....
		60	6	9	13	18	24	.....	.....	.....	.....	.....	.....
		90	9	13	18	24	30	.....	.....	.....	.....	.....	.....
4	All...	30	4.5	6.5	9.5	13.5	17	20	32	69	126	.....	.....
		60	6	9	13	18	22	25	40	80	137	.....	.....
		90	9	13	18	24	28	32	48	90	148	.....	.....
2	All...	30	4.5	6.5	9.5	13.5	14	16.5	24.5	50	86	193	.....
		60	6	9	13	18	18	20	30	59	98	208	.....
		90	9	13	18	24	23.5	25	37	69	110	222	.....
1	All...	30	4.5	6.5	9.5	13.5	14	16.5	23	44	74	163	362
		60	6	9	13	18	18	20	28	52	85	178	380
		90	9	13	18	24	23.5	25	34	61	96	193	396
0	All...	30	4.5	6.5	9.5	13.5	14	16.5	23	41	68	146	316
		60	6	9	13	18	18	20	27	49	79	159	335
		90	9	13	18	24	23.5	25	33	58	89	175	353
00	All...	30	4.5	6.5	9.5	13.5	14	16.5	22	39	62	125	276
		60	6	9	13	18	18	20	26	46	72	140	290
		90	9	13	18	24	23.5	25	32	54	83	154	309
0000	All...	30	4.5	6.5	9.5	13.5	14	16.5	20	37	57	113	225
		60	6	9	13	18	18	20	24	43	66	126	246
		90	9	13	18	24	23.5	25	29	51	76	141	264

TABLE 16.—Sags for Hard and Medium-Drawn Covered Copper Wire for Different Span Lengths

(At 30, 60, and 90° F—wires without load)

HEAVY LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F	In.	In.	In.	In.	In.	In.	In.
8	C..............	30	15	23	36	......	......	......	......
		60	18	27	40	......	......	......	......
		90	21.5	31	44	......	......	......	......
6	A..............	30	15	23	36	......	......	......	......
		60	18.	27	40	......	......	......	......
		90	21.5	31	45	......	......	......	......
6	B..............	30	11	17.5	27	......	......	......	......
		60	15	22	33	......	......	......	......
		90	18	26	38	......	......	......	......
6	C..............	30	8.5	14	22	31	......	......	......
		60	12	18	27	36	......	......	......
		90	15.5	22.5	32	40	......	......	......
4	All..............	30	8.5	14	21.5	31	43	......	......
		60	12	18	27	36	48	......	......
		90	17	22.5	32	41	54	......	......
2	All..............	30	8.5	14	21.5	23.5	30	53	89
		60	12	18	27	30	36	60	96
		90	17	22.5	32	35	42	67	103
1	All..............	30	8.5	13.5	21	23	27	44	72
		60	12	18	26	29	33	52	80
		90	15.5	22.5	31	34	39	59	87
0	All..............	30	8.5	13.5	20.5	22.5	26	42	66
		60	12	18	26	28	32	49	72
		90	15.5	22.5	31	34	38	56	82
00	All..............	30	8.5	13.5	20	22.5	25	38	57
		60	12	18	25	28	31	46	66
		90	16	22.5	30	34	38	53	73
0000	All..............	30	8.5	13.5	18.5	21	24.5	31	43
		60	12	18	24	27	30	38	50
		90	16	22.5	29	33	36	46	59

MEDIUM LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
8	C..............	30	11.5	18	29	......	......	......	......
		60	15	22	33	......	......	......	......
		90	18.5	26	37	......	......	......	......
6	A..............	30	11.5	18	28	......	......	......	......
		60	15	22	33	......	......	......	......
		90	18.5	26	37	......	......	......	......

14112°—21——12

TABLE 16—Continued

MEDIUM LOADING DISTRICTS—Continued

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F	In.	In.	In.	In.	In.	In.	In.
6	B	30	8.5	14	22	31	......	......	......
		60	12	18	27	36	......	......	......
		90	15.5	22	32	41	......	......	......
6	C	30	7.5	11	17.5	25	......	......	......
		60	10	15	22	30	......	......	......
		90	13.5	19	27	36	......	......	......
4	All	30	7	11.5	17.5	24	33	......	......
		60	10	15	22	30	39	......	......
		90	13.5	19.5	27	36	45	......	......
2	All	30	7	11.5	17.5	22.5	26	43	68
		60	10	15	22	27	32	50	76
		90	13.5	19.5	27	34	38	57	83
1	All	30	7	11	17	17.5	23.5	33	52
		60	10	15	22	25	29	39	60
		90	14	19.5	27	30	35	46	68
0	All	30	7	11	17.5	19.5	21.5	30	46
		60	10	15	22	24	27	36	54
		90	14	19.5	27	31	33	43	62
00	All	30	7	11	17	19	21	27	40
		60	10	15	22	24	26	33	48
		90	14	19.5	27	30	32	40	56
0000	All	30	7	11	17	18	19	23.5	33
		60	10	15	22	23	24	29	40
		90	13.5	19.5	27	29	30	35	47
LIGHT LOADING DISTRICTS									
8	C	30	8.5	14	22.5	31	......	......	......
		60	12	18	27	36	......	......	......
		90	15.5	22.5	32	41	......	......	......
6	A	30	8.5	14	22	31	......	......	......
		60	12	18	27	36	......	......	......
		90	15.5	22.5	32	41	......	......	......
6	B	30	7	11.5	17.5	25	32	......	......
		60	10	15	22	30	38	......	......
		90	13	19.5	27	36	44	......	......
6	C	30	6	9	14	19.5	26	......	......
		60	8	12	18	24	32	......	......
		90	11	16	22.5	29	38	......	......
4	All	30	6.5	9	14	19	26	......	......
		60	8	12	18	24	32	......	......
		90	11.5	16	22	30	38	......	......

TABLE 16—Continued

LIGHT LOADING DISTRICTS—Continued

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F	In.	In.	In.	In.	In.	In.	In.
2	All	30	6.5	9	14	17.5	21	28	45
		60	8	12	18	22	26	34	52
		90	11.5	16	22	27	32	41	60
1	All	30	5.5	9	13.5	16.5	19	26	38
		60	8	12	18	21	24	31	45
		90	11.5	16	23	26	30	38	53
0	All	30	5.5	9	14	16.5	18	24.5	34
		60	8	12	18	21	23	30	41
		90	11.5	16.5	23	27	28	36	47
00	All	30	5.5	9	13.5	16	17.5	23	31
		60	8	12	18	20	22	28	37
		90	11.5	16	23	25	28	35	45
0000	All	30	5.5	8.5	13.5	16	16.5	20.5	27
		60	8	12	18	19	21	25	32
		90	11	16	23	24.5	26	31	39

TABLE 17.—Sags for Soft-Drawn Covered Copper Wires for Different Span Lengths

(At 30°, 60°, and 90° F—wires without load)

HEAVY LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—				
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.
		°F	In.	In.	In.	In.	In.
6	C	30	18	28	44	....	....
		60	21	32	48	....	....
		90	24	36	51	....	....
4	A	30	17.5	28	45	....	....
		60	21	32	48	....	....
		90	24	35	51	....	....
4	B and C	30	14.5	23	36	....	....
		60	18	27	40	....	....
		90	21.5	31	44	....	....
2	A	30	14.5	23	36	49	....
		60	18	27	40	54	....
		90	21.5	31	44	58	....
2	B and C	30	11	17.5	28	40	55
		60	15	22	33	45	60
		90	18.5	26	38	50	64

TABLE 17—Continued

HEAVY LOADING DISTRICTS—Continued

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—				
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.
		° F	In.	In.	In.	In.	In.
1	A	30	10.5	17.5	28	40	55
		60	15	22	33	45	60
		90	18.5	26	37	50	65
1	B and C	30	8.5	13.5	21.5	31	43
		60	12	18	27	37	48
		90	15.5	22.5	32	42	53
0	All	30	8.5	13.5	20.5	29	39
		60	12	18	26	35	45
		90	15.5	22.5	31	39	51
00	All	30	8.5	13.5	20	28	36
		60	12	18	25	33	42
		90	15.5	22.5	30	38	48
0000	All	30	8.5	13.5	18.5	24.5	30
		60	12.	18	24	30	36
		90	16	22.5	29	36	42

MEDIUM LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of—					
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.
		° F	In.	In.	In.	In.	In.	In.
6	C	30	14.5	22	36	....	....	....
		60	18	27	40	....	....	....
		90	21	31	44	....	....	....
4	All	30	11	18	28	44	....	....
		60	15	22	33	48	....	....
		90	18.5	26	37	53	....	....
2	All	30	8.5	13.5	22.5	31	43	....
		60	12	18	27	36	48	....
		90	15.5	22	32	41	53	....
1	All	30	8.5	13.5	20	28	36	53
		60	12	18	25	33	42	60
		90	15.5	22.5	30	38	48	67
0	All	30	8.5	13.5	19	25	33	47
		60	12	18	24	31	39	54
		90	15.5	22.5	29	37	45	61

TABLE 17—Continued

MEDIUM LOADING DISTRICTS—Continued

Size A. W. G. No.	Grade of construction	Temperature	Sags for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.
		° F	In.	In.	In.	In.	In.	In.
00	All	30	8.5	13.5	19	24.5	30	41
		60	12	18	24	30	36	48
		90	15.5	22.5	29	36	42	55
0000	All	30	8.5	13.5	18.5	24.5	30	41
		60	12	18	24	30	36	48
		90	16	22.5	29	36	42	55

LIGHT LOADING DISTRICTS

Size A. W. G. No.	Grade of construction	Temperature	100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.
		° F	In.	In.	In.	In.	In.	In.
6	A	30	14	23	36	....	....	....
		60	18	27	40	....	....	....
		90	21.5	31	44	....	....	....
6	B and C	30	11	17.5	39	....	....	....
		60	15	22	33	....	....	....
		90	18.5	26	37	....	....	....
4	All	30	8.5	13.5	20	26	36	....
		60	12	18	25	32	42	....
		90	15.5	22.5	30	37	47	....
2	All	30	7	11	16	22	30	41
		60	10	15	21	27	36	48
		90	13.5	19.5	26	33	42	55
1	All	30	7	11	15	19.5	24	35
		60	10	15	20	25	30	42
		90	14	19.5	25	31	36	49
0	All	30	7	11	15.5	20	24.5	35
		60	10	15	20	25	30	42
		90	14	19.5	25	31	36	49
00	All	30	7	11	15	19.5	24	35
		60	10	15	20	25	30	42
		90	14	19.5	25	31	36	49
0000	All	30	7	10.5	15.5	19.5	24	35
		60	10	15	20	25	30	42
		90	14	19.5	25	31	36	49

TABLE 18.—Tensions in Hard and Medium-Drawn Bare Copper Wire for Different Span Lengths

HEAVY LOADING DISTRICTS[a]

Size A.W.G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.
		°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
8	C	30 no load	94	92	76	....	....	....	....	....	....
		60 no load	63	65	62	....	....	....	....	....	....
		90 no load	47	53	54	....	....	....	....	....	....
		0 loaded	442	503	520	....	....	....	....	....	....
6	A	30 no load	150	145	120	....	....	....	....	....	....
		60 no load	99	105	99	....	....	....	....	....	....
		90 no load	74	85	86	....	....	....	....	....	....
		0 loaded	570	630	670	....	....	....	....	....	....
6	B	30 no load	180	180	165	....	....	....	....	....	....
		60 no load	120	125	120	....	....	....	....	....	....
		90 no load	84	95	100	....	....	....	....	....	....
		0 loaded	590	650	710	....	....	....	....	....	....
6	C	30 no load	180	180	165	125	....	....	....	....	....
		60 no load	120	125	120	110	....	....	....	....	....
		90 no load	84	95	100	96	....	....	....	....	....
		0 loaded	590	650	710	740	....	....	....	....	....
4	All	30 no load	290	280	270	260	240	185	160	....	....
		60 no load	190	200	200	210	200	170	150	....	....
		90 no load	135	150	160	175	170	155	145	....	....
		0 loaded	740	840	900	960	1000	1000	990	....	....
2	All	30 no load	460	450	510	590	650	540	470	380	350
		60 no load	300	310	380	440	500	430	400	350	340
		90 no load	210	240	290	340	400	370	370	340	330
		0 loaded	1000	1100	1250	1350	1450	1550	1550	1600	1600
1	All	30 no load	580	520	650	740	820	730	670	540	490
		60 no load	380	400	470	550	630	600	580	510	470

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft.	1000 ft.
		90 no load	270	300	370	430	500	500	520	480	450		
		0 loaded	1200	1250	1450	1600	1700	1800	1900	1900	1900		
0	All	39 no load	730	720	820	930	1050	970	950	760	710		
		60 no load	480	500	600	700	800	790	790	710	670		
		90 no load	340	380	460	540	630	660	690	650	630		
		0 loaded	1400	1500	1650	1850	2000	2150	2200	2300	2250		
00	All	30 no load	920	910	1050	1150	1300	1300	1300	1050	960		
		60 no load	600	630	750	880	1000	1050	1100	950	910		
		90 no load	430	480	580	680	790	850	930	880	850		
		0 loaded	1700	1750	1950	2150	2350	2550	2900	2650	2650		
0000	All	30 no load	1450	1450	1650	1850	2050	2300	2500	2100	2000		
		60 no load	960	1000	1200	1400	1600	1850	2050	1850	1850		
		90 no load	680	770	930	1100	1250	1500	1700	1650	1700		
		0 loaded	2500	2500	2800	3100	3350	3750	4100	4000	4150		

MEDIUM LOADING DISTRICTS [a]

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—										
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft.	1000 ft.
		°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
8	C	30 no load	140	140	130	...	...	...	...	...	...	...	...
		60 no load	94	97	94	...	...	...	...	...	...	...	...
		90 no load	63	71	73	...	...	...	...	...	...	...	...
		15 loaded	370	410	440	...	...	...	...	...	...	...	...
6	All	30 no load	230	220	200	200	...	...	...	...	...	...	...
		60 no load	150	155	150	150	...	...	...	...	...	...	...
		90 no load	100	110	115	125	...	...	...	...	...	...	...
		15 loaded	480	540	570	610	...	...	...	...	...	...	...
4	All	30 nol oad	360	360	320	320	300	340	280	230	...	...	...
		60 no load	240	250	240	240	240	280	250	220	...	...	...
		90 no load	160	180	185	200	200	240	220	200	...	...	...
		15 loaded	630	690	730	780	800	920	930	940	...	...	...

[a] Correspond to the sags of Table 15

TABLE 18—Continued

MEDIUM LOADING DISTRICTS—Continued

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft.	1000 ft.
		°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
2	All..........	30 no load.........	570	570	510	550	600	650	650	620	540	480	....
		60 no load.........	380	390	380	420	460	520	540	550	500	460	....
		90 no load.........	260	280	300	290	370	430	470	460	470	450	....
		15 loaded..........	880	940	950	1050	1100	1250	1350	1500	1500	1500	....
1	All..........	30 no load.........	720	710	650	740	840	950	1050	980	850	680	....
		60 no load.........	480	490	470	550	630	760	850	850	770	650	....
		90 no load.........	320	360	370	420	490	610	700	740	700	620	....
		15 loaded..........	1050	1100	1100	1250	1350	1550	1700	1850	1850	1800	....
0	All..........	30 no load.........	910	900	820	940	1050	1300	1450	1400	1250	1050	....
		60 no load.........	600	620	600	710	830	1050	1200	1200	1100	980	....
		90 no load.........	400	450	470	540	650	830	980	1050	1000	930	....
		15 loaded..........	1250	1300	1300	1450	1600	1850	2100	2350	2300	2200	....
00	All..........	30 no load.........	1150	1150	1050	1250	1400	1750	2000	2050	1850	1650	1550
		60 no load.........	760	780	750	920	1100	1400	1650	1750	1650	1550	1450
		90 no load.........	510	570	590	720	850	1150	1350	1500	1450	1450	1400
		15 loaded..........	1500	1550	1550	1800	1950	2350	2650	2900	2900	2950	3000
0000	All..........	30 no load.........	1800	1800	1650	2050	2400	3150	3800	3800	3650	3350	3150
		60 no load.........	1200	1250	1200	1550	1800	2500	3200	3200	3150	3050	3000
		90 no load.........	810	900	940	1200	1400	2000	2600	2700	2750	2750	2850
		15 loaded..........	2300	2350	2200	2600	3000	3750	4500	4550	4600	4600	4700

LIGHT LOADING DISTRICTS[a]

8	C........	30 no load........	180	180	175	150	....	....	....	....	....	....	....
		60 no load........	125	130	130	115	....	....	....	....	....	....	....
		90 no load........	82	91	94	90	....	....	....	....	....	....	....
		30 loaded........	310	340	360	390	....	....	....	....	....	....	....
6	All........	30 no load........	280	290	280	270	260	....	....	....	....	....	....
		60 no load........	200	210	210	200	200	....	....	....	....	....	....
		90 no load........	130	145	150	155	160	....	....	....	....	....	....
		30 loaded........	410	450	480	520	530	....	....	....	....	....	....
4	All........	30 no load........	450	460	450	430	450	590	520	440	380	....	....
		60 no load........	320	330	330	320	340	470	430	380	340	....	....
		90 no load........	210	230	240	240	270	370	350	340	320	....	....
		30 loaded........	560	610	640	660	710	860	880	930	940	....	....
2	All........	30 no load........	710	730	710	680	870	1150	1100	960	870	760	....
		60 no load........	510	520	520	510	670	940	900	820	770	710	....
		90 no load........	330	370	380	390	510	750	730	700	680	660	....
		30 loaded........	810	850	870	890	1050	1360	1350	1400	1400	1450	....
1	All........	30 no load........	900	920	890	860	1100	1450	1450	1400	1300	1150	1050
		60 no load........	640	660	650	640	840	1200	1200	1150	1100	1050	1000
		90 no load........	410	460	480	490	650	940	990	990	980	970	970
		30 loaded........	980	1000	1050	1050	1250	1600	1700	1750	1750	1800	1800
0	All........	30 no load........	1150	1150	1150	1100	1400	1800	1900	1800	1750	1600	1500
		60 no load........	800	830	830	810	1050	1500	1600	1550	1500	1450	1450
		90 no load........	520	580	600	620	820	1200	1300	1300	1350	1350	1350
		30 loaded........	1200	1250	1250	1250	1500	1950	2100	2150	2150	2200	2250
00	All........	30 no load........	1450	1450	1400	1350	1750	2300	2500	2450	2400	2350	2200
		60 no load........	1000	1050	1050	1050	1350	1900	2100	2100	2100	2100	2100
		90 no load........	660	730	760	780	1050	1500	1700	1800	1800	1900	1950
		30 loaded........	1500	1550	1500	1500	1850	2400	2650	2650	2750	2800	2800
0000	All........	30 no load........	2200	2350	2250	2150	2750	3650	4300	4200	4200	4150	4250
		60 no load........	1600	1650	1650	1650	2100	3000	3600	3550	3600	3700	3900
		90 no load........	1050	1150	1200	1250	1650	2400	2950	3000	3150	3350	3650
		30 loaded........	2350	2400	2350	2400	2900	3750	4400	4350	4450	4550	4700

[a] Correspond to the sags of Table 15

TABLE 19.—Tensions in Hard and Medium-Drawn Covered Copper Wire for Different Span Lengths

HEAVY LOADING DISTRICTS [a]

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
8	C..........	30 no load.........	77	77	72	......	......	......	......
		60 no load.........	62	65	63	......	......	......	......
		90 no load.........	54	58	59	......	......	......	......
		0 loaded..........	470	520	560	......	......	......	......
6	A..........	30 no load.........	115	115	105	......	......	......	......
		60 no load.........	94	98	95	......	......	......	......
		90 no load.........	81	87	87	......	......	......	......
		0 loaded..........	580	640	670	......	......	......	......
6	B..........	30 no load.........	155	155	135	......	......	......	......
		60 no load.........	110	120	115	......	......	......	......
		90 no load.........	94	105	105	......	......	......	......
		0 loaded..........	600	680	720	......	......	......	......
6	C..........	30 no load.........	195	190	170	165	......	......	......
		60 no load.........	140	145	140	145	......	......	......
		90 no load.........	108	120	120	130	......	......	......
		0 loaded..........	640	710	760	820	......	......	......
4	All..........	30 no load.........	270	280	260	240	230	......	......
		60 no load.........	210	210	210	210	210	......	......
		90 no load.........	155	170	175	185	185	......	......
		0 loaded..........	820	900	950	1000	1050	......	......
2	All..........	30 no load.........	430	440	410	500	530	460	400
		60 no load.........	330	340	330	400	430	410	370
		90 no load.........	250	270	280	340	380	370	320
		0 loaded..........	1100	1150	1200	1350	1500	1550	1500
1	All..........	30 no load.........	560	540	510	630	710	660	590
		60 no load.........	400	410	410	500	570	570	540
		90 no load.........	310	330	350	430	490	510	490
		0 loaded..........	1200	1300	1350	1550	1700	1700	1850
0	All..........	30 no load.........	710	690	670	820	930	910	870
		60 no load.........	510	530	530	660	750	780	770
		90 no load.........	390	430	450	550	630	680	680
		0 loaded..........	1450	1550	1600	1850	2000	2050	2200
00	All..........	30 no load.........	890	860	840	1000	1200	1200	1200
		60 no load.........	630	650	680	830	970	1000	1050
		90 no load.........	480	520	570	680	810	890	910
		0 loaded..........	1700	1800	1850	2100	2350	2500	2600
0000	All..........	30 no load.........	1350	1350	1400	1650	1850	2250	2450
		60 no load.........	960	1000	1100	1300	1550	1900	2050
		90 no load.........	730	810	920	1100	1300	1600	1750
		0 loaded..........	2450	2500	2650	3000	3300	3850	4200

[a] Correspond to the sags of Table 16.

TABLE 19—Continued

MEDIUM LOADING DISTRICTS [a]

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
8	C...........	30 no load.........	98	98	89	......	......	......	......
		60 no load.........	75	80	76	......	......	......	......
		90 no load.........	61	68	69	......	......	......	......
		15 loaded..........	370	400	430	......	......	......	......
6	A...........	30 no load.........	150	150	135	......	......	......	......
		60 no load.........	115	120	115	......	......	......	......
		90 no load.........	93	100	105	......	......	......	......
		15 loaded..........	460	510	530	......	......	......	......
6	B...........	30 no load.........	195	190	170	170	......	......	......
		60 no load.........	140	145	140	145	......	......	......
		90 no load.........	110	120	120	130	......	......	......
		15 loaded..........	510	540	570	610	......	......	......
6	C...........	30 no load.........	230	230	220	210	......	......	......
		60 no load.........	170	175	170	175	......	......	......
		90 no load.........	125	140	140	150	......	......	......
		15 loaded..........	520	570	610	650	......	......	......
4	All..........	30 no load.........	350	340	320	290	300	......	......
		60 no load.........	250	260	250	250	250	......	......
		90 no load.........	180	200	210	210	220	......	......
		15 loaded..........	670	730	770	800	850	......	......
2	All..........	30 no load.........	560	540	510	530	600	560	520
		60 no load.........	390	410	400	440	490	490	470
		90 no load.........	290	320	330	360	410	430	430
		15 loaded..........	910	970	1000	1100	1200	1250	1250
1	All..........	30 no load.........	670	670	620	750	820	900	830
		60 no load.........	470	490	490	580	660	760	710
		90 no load.........	350	390	390	480	540	640	630
		15 loaded..........	1050	1100	1100	1300	1400	1600	1600
0	All..........	30 no load.........	870	850	790	950	1100	1250	1200
		60 no load.........	610	630	620	710	900	1050	1000
		90 no load.........	440	490	510	610	730	880	890
		15 loaded..........	1250	1300	1300	1500	1700	1950	1950
00	All..........	30 no load.........	1050	1050	990	1200	1450	1750	1650
		60 no load.........	750	780	770	960	1150	1400	1400
		90 no load.........	550	610	630	780	950	1200	1200
		15 loaded..........	1500	1550	1500	1800	2050	2400	2450
0000	All..........	30 no load.........	1700	1650	1500	1950	2400	3050	3100
		60 no load.........	1150	1200	1200	1550	1900	2450	2600
		90 no load.........	840	920	970	1250	1550	2100	2200
		15 loaded..........	2200	2350	2100	2600	3100	3700	3950

[a] Correspond to the sags of Table 16.

TABLE 19—Continued

LIGHT LOADING DISTRICTS[a]

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Tensions for span length of—						
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
8	C	30 no load	130	125	115	115	......	......	......
		60 no load	94	97	94	96	......	......	......
		90 no load	73	79	79	84	......	......	......
		30 loaded	300	330	350	370	......	......	......
6	A	30 no load	195	190	170	170	......	......	......
		60 no load	140	150	140	145	......	......	......
		90 no load	110	120	120	130	......	......	......
		30 loaded	370	410	430	450	......	......	......
6	B	30 no load	250	230	220	210	200	......	......
		60 no load	170	175	175	170	180	......	......
		90 no load	130	140	140	145	155	......	......
		30 loaded	410	440	460	490	530	......	......
6	C	30 no load	290	290	270	270	260	......	......
		60 no load	210	220	210	220	210	......	......
		90 no load	155	165	170	180	180	......	......
		30 loaded	440	480	500	540	560	......	......
4	All	30 no load	430	430	390	390	380	......	......
		60 no load	310	320	310	310	310	......	......
		90 no load	220	240	230	250	260	......	......
		30 loaded	570	620	640	670	690	......	......
2	All	30 no load	690	680	630	690	740	870	790
		60 no load	490	510	490	540	600	720	670
		90 no load	340	380	360	430	490	600	590
		30 loaded	810	850	840	930	1000	1200	1200
1	All	30 no load	840	840	790	890	1000	1150	1100
		60 no load	600	620	600	700	790	960	950
		90 no load	410	460	470	560	640	790	810
		30 loaded	960	990	970	1100	1250	1450	1450
0	All	30 no load	1050	1050	990	1100	1350	1550	1600
		60 no load	760	790	750	890	1050	1250	1350
		90 no load	540	590	590	700	850	1050	1150
		30 loaded	1150	1200	1150	1300	1500	1750	1900
00	All	30 no load	1350	1350	1250	1450	1700	2050	2150
		60 no load	950	990	940	1150	1350	1650	1800
		90 no load	660	730	740	900	1100	1350	1550
		30 loaded	1400	1450	1350	1600	1850	2200	2350
0000	All	30 no load	2150	2100	1900	2400	2750	3500	3850
		60 no load	1450	1500	1450	1850	2200	2850	3200
		90 no load	1050	1100	1150	1450	1750	2350	2700
		30 loaded	2200	2200	2050	2550	2900	3650	4100

[a] Correspond to the sags of Table 16.

TABLE 20.—Tensions in Soft-Drawn Covered Copper Wire for Different Span Lengths

HEAVY LOADING DISTRICTS [a]

Size A.W.G. No.	Grade of construction	Condition of load and temperature	Tensions for span length of—				
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.
		°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
6	C	30 no load	97	94	87		
		60 no load	82	85	80		
		90 no load	71	76	75		
		0 loaded	540	590	610		
4	A	30 no load	140	140	125		
		60 no load	120	120	115		
		90 no load	105	115	110		
		0 loaded	670	710	720		
4	B and C	30 no load	175	165	155		
		60 no load	140	145	140		
		90 no load	115	130	130		
		0 loaded	720	770	800		
2	A	30 no load	280	270	250	240	
		60 no load	220	230	220	225	
		90 no load	185	200	200	210	
		0 loaded	900	970	970	1050	
2	B and C	30 no load	350	350	310	300	290
		60 no load	260	280	270	270	260
		90 no load	210	240	240	240	240
		0 loaded	980	1050	1100	1100	1150
1	A	30 no load	430	430	380	370	350
		60 no load	320	340	330	330	320
		90 no load	260	290	290	300	300
		0 loaded	1100	1200	1200	1250	1250
1	B and C	30 no load	560	540	490	470	450
		60 no load	390	410	400	400	400
		90 no load	310	330	340	350	360
		0 loaded	1250	1300	1350	1400	1450
0	All	30 no load	710	690	670	630	630
		60 no load	510	530	530	530	540
		90 no load	460	430	450	480	480
		0 loaded	1450	1550	1600	1600	1700
00	All	30 no load	890	860	850	840	840
		60 no load	630	650	680	700	720
		90 no load	490	520	570	600	640
		0 loaded	1700	1800	1850	1900	2000
0000	All	30 no load	1350	1350	1400	1450	1550
		60 no load	960	1000	1100	1200	1300
		90 no load	730	810	900	1000	1100
		0 loaded	2400	2500	2600	2750	3000

[a] Correspond to sags of Table 17.

TABLE 20—Continued

MEDIUM LOADING DISTRICTS [a]

Size A. W. G. No.	Grade of construction	Condition of load and temperature	Tensions for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.
		°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
6	C	30 no load	120	120	105			
		60 no load	95	99	96			
		90 no load	80	88	88			
		15 loaded	420	470	490			
4	All	30 no load	220	220	195	170		
		60 no load	165	175	170	160		
		90 no load	135	145	150	145		
		15 loaded	570	630	640	640		
2	All	30 no load	450	450	390	390	370	
		60 no load	330	340	330	330	330	
		90 no load	250	280	280	290	300	
		15 loaded	830	890	900	940	940	
1	All	30 no load	560	540	540	530	530	560
		60 no load	400	410	430	440	450	500
		90 no load	310	330	360	380	400	450
		15 loaded	960	1000	1050	1100	1150	1250
0	All	30 no load	710	690	720	730	740	810
		60 no load	510	530	560	600	620	700
		90 no load	390	430	470	510	540	630
		15 loaded	1150	1150	1250	1300	1350	1500
00	All	30 no load	890	860	900	950	1000	1150
		60 no load	630	650	700	770	840	980
		90 no load	480	520	590	650	720	860
		15 loaded	1300	1350	1450	1550	1650	1850
0000	All	30 no load	1350	1350	1400	1450	1550	1750
		60 no load	960	1000	1100	1200	1300	1500
		90 no load	730	810	900	1000	1100	1300
		15 loaded	1850	1900	1950	2100	2200	2500

[a] Correspond to sags of Table 17.

TABLE 20—Continued

LIGHT LOADING DISTRICTS [a]

Size A. W. G. No.	Grade of construction	Condition of load and temperature	Tensions for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.
		°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
6	A	30 no load	120	115	105	......	......	......
		60 no load	95	99	97	......	......	......
		90 no load	80	88	89	......	......	......
		30 loaded	320	340	350	......	......	......
6	B and C	30 no load	150	150	135	......	......	......
		60 no load	115	120	115	......	......	......
		90 no load	92	105	105	......	......	......
		30 loaded	340	380	390	......	......	......
4	All	30 no load	290	280	280	280	280	......
		60 no load	210	220	220	230	230	......
		90 no load	155	175	185	210	210	......
		30 loaded	480	510	550	590	610	......
2	All	30 no load	560	550	540	550	520	600
		60 no load	390	410	410	440	440	510
		90 no load	290	320	340	370	700	440
		30 loaded	700	740	770	810	830	950
1	All	30 no load	690	680	700	740	790	850
		60 no load	480	490	530	580	630	710
		90 no load	350	390	430	480	730	610
		30 loaded	810	850	920	980	1050	1200
0	All	30 no load	860	850	890	940	990	1100
		60 no load	600	630	690	750	810	910
		90 no load	440	490	550	610	670	780
		30 loaded	970	1000	1050	1150	1200	1350
00	All	30 no load	1100	1050	1100	1150	1250	1350
		60 no load	760	780	840	920	1000	1100
		90 no load	550	610	680	760	840	960
		30 loaded	1150	1200	1250	1350	1400	1550
0000	All	30 no load	1700	1650	1700	1800	1900	2050
		60 no load	1150	1200	1300	1400	1550	1700
		90 no load	840	930	870	1150	1250	1450
		30 loaded	1750	1750	1850	1950	2100	2300

[a] Correspond to sags of Table 17.

TABLE 21.—Stresses in Hard and Medium-Drawn Bare Copper Wire for Different Span Lengths

HEAVY LOADING DISTRICTS [a]

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.
		°F	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²
8	C	30 no load	7 200	7 150	5 900	....	....	....	....	....	....
		60 no load	4 800	5 000	4 800	....	....	....	....	....	....
		90 no load	3 600	4 100	4 150	....	....	....	....	....	....
		0 loaded	34 100	38 800	40 250	....	....	....	....	....	....
6	A	30 no load	7 200	7 150	5 900	....	....	....	....	....	....
		60 no load	4 800	5 000	4 800	....	....	....	....	....	....
		90 no load	3 600	4 100	4 150	....	....	....	....	....	....
		0 loaded	27 400	30 500	32 350	....	....	....	....	....	....
6	B	30 no load	8 800	8 700	8 000	....	....	....	....	....	....
		60 no load	5 800	6 000	5 900	....	....	....	....	....	....
		90 no load	4 100	4 650	4 850	....	....	....	....	....	....
		0 loaded	28 400	31 750	34 400	....	....	....	....	....	....
6	C	30 no load	8 800	8 700	8 000	6 150	....	....	....	....	....
		60 no load	5 800	6 000	5 900	5 350	....	....	....	....	....
		90 no load	4 100	4 650	4 850	4 650	....	....	....	....	....
		0 loaded	28 400	31 750	34 400	35 900	....	....	....	....	....
4	All	30 no load	8 800	8 700	8 200	8 000	7 200	5 600	4 850	....	....
		60 no load	5 800	6 000	6 150	6 300	6 100	5 100	4 550	....	....
		90 no load	4 100	4 650	4 950	5 350	5 250	4 700	4 400	....	....
		0 loaded	22 700	25 700	27 400	29 400	30 500	30 600	30 300	....	....
2	All	30 no load	8 800	8 700	9 850	11 200	12 400	10 300	8 950	7 250	6 650
		60 no load	5 800	6 000	7 200	8 400	9 600	8 250	7 700	6 800	6 500
		90 no load	4 100	4 650	5 600	6 450	7 600	7 150	7 000	6 500	6 250
		0 loaded	19 400	21 000	23 650	26 000	28 100	29 300	30 200	30 500	30 900
1	All	30 no load	8 800	8 700	9 850	11 200	12 400	11 150	10 250	8 250	7 500
		60 no load	5 800	6 000	7 200	8 400	9 600	9 100	8 850	7 750	7 150

		90 no load	4 100	4 650	5 600	6 450	7 600	7 600	7 850	7 300	6 850
		0 loaded	18 200	19 250	21 700	24 000	26 000	27 500	28 700	28 900	29 000
0	All	30 no load	8 800	8 700	9 850	11 200	12 400	11 700	11 400	9 200	8 550
		60 no load	5 800	6 000	7 200	8 400	9 600	9 500	9 500	8 500	8 050
		90 no load	4 100	4 650	5 600	6 450	7 600	7 900	8 250	7 800	7 600
		0 loaded	17 100	18 200	20 200	22 200	24 150	26 000	26 800	27 500	27 000
00	All	30 no load	8 800	8 700	9 850	11 200	12 400	12 400	12 500	10 100	9 250
		60 no load	5 800	6 000	7 200	8 400	9 600	10 000	10 400	9 100	8 650
		90 no load	4 100	4 650	5 600	6 450	7 600	8 150	8 950	8 400	8 100
		0 loaded	16 100	16 800	18 800	20 800	22 500	24 200	27 600	25 400	25 400
0000	All	30 no load	8 800	8 700	9 850	11 200	12 400	13 850	15 100	12 550	12 150
		60 no load	5 800	6 000	7 200	8 400	9 600	11 250	12 350	11 050	11 000
		90 no load	4 100	4 650	5 600	6 450	7 600	9 050	10 350	9 850	10 150
		0 loaded	15 000	15 100	16 900	18 600	20 100	22 700	24 600	24 000	24 850

MEDIUM LOADING DISTRICTS[a]

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of—										
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft.	1000 ft.
		° F	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}
8	C	30 no load	10 900	10 850	9 850	....	....	....	....	....	....	....	....
		60 no load	7 250	7 500	7 200	....	....	....	....	....	....	....	....
		90 no load	4 900	5 450	5 650	....	....	....	....	....	....	....	....
		15 loaded	28 500	31 900	34 200	....	....	....	....	....	....	....	....
6	All	30 no load	10 900	10 850	9 850	9 600	....	....	....	....	....	....	....
		60 no load	7 250	7 500	7 200	7 400	....	....	....	....	....	....	....
		90 no load	4 900	5 450	5 650	6 000	....	....	....	....	....	....	....
		15 loaded	23 200	25 700	27 400	29 300	....	....	....	....	....	....	....
4	All	30 no load	10 900	10 850	9 850	9 600	9 250	10 450	8 650	6 950	....	....	....
		60 no load	7 250	7 500	7 200	7 400	7 250	8 600	7 600	6 600	....	....	....
		90 no load	4 900	5 450	5 650	6 000	6 050	7 250	6 850	6 250	....	....	....
		15 loaded	19 350	21 050	22 150	23 650	24 500	28 000	28 400	28 800	....	....	....

[a] Correspond to the tensions of Table 18.

TABLE 21—Continued

MEDIUM LOADING DISTRICTS—Continued

Size A. W. G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	700 ft.	1000 ft.
		°F	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}
2	All........	30 no load.....	10 900	10 850	9 850	10 650	11 450	12 400	12 550	11 900	10 400	9 190	....
		60 no load.....	7 250	7 500	7 200	8 000	8 900	10 000	10 300	10 500	9 650	8 800	....
		90 no load.....	4 900	5 450	5 650	5 650	7 000	8 150	8 950	8 900	9 000	8 600	....
		15 loaded.....	16 800	18 000	18 250	20 000	21 500	24 200	26 100	28 400	28 650	28 500	....
1	All........	30 no load.....	10 900	10 850	9 850	11 250	12 700	14 500	15 900	14 950	12 950	10 300	....
		60 no load.....	7 250	7 500	7 200	8 350	9 600	11 550	12 900	12 850	11 700	9 850	....
		90 no load.....	4 900	5 450	5 650	6 450	7 500	9 350	10 700	11 200	10 700	9 500	....
		15 loaded.....	15 800	16 800	16 900	18 750	20 650	23 600	26 200	28 300	28 300	27 100	....
0	All........	30 no load.....	10 900	10 850	9 850	11 350	12 900	15 550	17 600	17 150	15 250	12 550	....
		60 no load.....	7 250	7 500	7 200	8 600	10 000	12 400	14 200	14 500	13 300	11 800	....
		90 no load.....	4 900	5 450	5 650	6 500	7 850	10 000	11 800	12 500	12 000	11 150	....
		15 loaded.....	15 150	15 800	15 650	17 700	19 500	22 000	25 500	28 500	27 450	26 800	....
00	All........	30 no load.....	10 900	10 850	9 850	11 750	13 550	16 900	19 200	19 750	17 850	16 000	14 750
		60 no load.....	7 250	7 500	7 200	8 800	10 450	13 300	15 650	16 750	15 700	14 800	14 100
		90 no load.....	4 900	5 450	5 650	6 900	8 150	10 800	12 750	14 300	13 900	13 850	13 650
		15 loaded.....	14 500	15 050	14 700	17 000	18 700	22 500	25 500	27 800	27 500	28 150	28 550
0000	All........	30 no load.....	10 900	10 850	9 850	12 250	14 300	18 850	22 800	22 750	21 850	20 250	19 050
		60 no load.....	7 250	7 500	7 200	9 250	10 950	15 000	19 150	19 200	18 900	18 300	18 000
		90 no load.....	4 900	5 450	5 650	7 150	8 500	12 000	15 650	16 200	16 400	16 650	17 050
		15 loaded.....	13 800	14 000	13 250	15 750	17 950	22 550	27 050	27 500	27 500	27 700	28 200

LIGHT LOADING DISTRICTS[a]

8	C	30 no load	13 700	14 000	13 550	11 750							
		60 no load	9 700	10 000	9 950	8 800							
		90 no load	6 300	7 000	7 250	6 900							
		30 loaded	23 650	26 300	28 000	29 950							
6	All	30 no load	13 700	14 000	13 550	13 000	12 450						
		60 no load	9 700	10 000	9 950	9 800	9 600						
		90 no load	6 300	7 000	7 250	7 450	7 600						
		30 loaded	19 700	21 700	23 150	25 200	25 750						
4	All	30 no load	13 700	14 000	13 550	13 000	13 600	18 000	15 850	13 400	11 500		
		60 no load	9 700	10 000	9 950	9 800	10 500	14 400	12 950	11 550	10 500		
		90 no load	6 300	7 000	7 250	7 450	8 200	11 400	10 700	10 300	9 750		
		30 loaded	17 100	18 500	19 400	20 200	21 700	26 300	26 900	28 300	28 750		
2	All	30 no load	13 700	14 000	13 550	13 000	16 600	21 900	21 100	18 400	16 700	14 650	
		60 no load	9 700	10 000	9 950	9 800	12 750	18 000	17 250	15 650	14 750	13 650	
		90 no load	6 300	7 000	7 250	7 450	9 850	14 300	14 000	13 450	13 100	12 700	
		30 loaded	15 500	16 300	16 750	17 100	20 300	25 900	26 300	26 400	27 000	27 800	
1	All	30 no load	13 700	14 000	13 550	13 000	16 600	21 900	22 350	21 000	19 500	17 800	16 000
		60 no load	9 700	10 000	9 950	9 800	12 750	18 000	18 500	17 650	16 950	15 800	15 250
		90 no load	6 300	7 000	7 250	7 450	9 850	14 300	15 000	15 050	14 900	14 700	14 700
		30 loaded	14 850	15 550	15 900	15 950	19 250	24 700	25 750	26 400	26 700	27 300	27 750
0	All	30 no load	13 700	14 000	13 550	13 000	16 600	21 900	22 800	21 850	21 150	19 400	18 300
		60 no load	9 700	10 000	9 950	9 800	12 750	18 000	19 150	18 900	18 250	17 750	17 250
		90 no load	6 300	7 000	7 250	7 450	9 850	14 300	15 650	15 900	16 050	16 150	16 500
		30 loaded	14 500	15 000	15 100	15 000	18 300	23 650	25 300	26 000	25 900	26 450	27 000
00	All	30 no load	13 700	14 000	13 550	13 000	16 600	21 900	23 850	23 700	23 100	22 500	20 900
		60 no load	9 700	10 000	9 950	9 800	12 750	18 000	20 000	20 050	19 900	20 200	19 900
		90 no load	6 300	7 000	7 250	7 450	9 850	14 300	16 350	17 000	17 350	18 300	18 700
		30 loaded	14 200	14 600	14 500	14 300	17 750	23 000	25 300	25 350	26 100	26 800	26 800
0000	All	30 no load	13 700	14 000	13 550	13 000	16 600	21 900	25 700	25 150	25 250	25 000	25 600
		60 no load	9 700	10 000	9 950	9 800	12 750	18 000	21 550	21 400	21 700	22 400	23 500
		90 no load	6 300	7 000	7 250	7 450	9 850	14 300	17 850	18 150	18 850	20 000	21 850
		30 loaded	14 000	14 350	14 100	13 750	17 350	22 500	26 400	26 250	26 750	27 300	28 300

[a] Correspond to the tensions of Table 18.

TABLE 22.—Stresses in Hard and Medium-Drawn Covered Copper Wire for Different Span Lengths

HEAVY LOADING DISTRICTS[a]

Size A.W.G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}
8	C.....	30 no load ...	5 900	5 900	5 550	....	....	....	....
		60 no load ...	4 800	5 050	4 900	....	....	....	....
		90 no load ...	4 150	4 500	4 550	....	....	....	....
		0 loaded	35 900	40 000	42 800	....	....	....	....
6	A.....	30 no load ...	5 550	5 600	5 150	....	....	....	....
		60 no load ...	4 550	4 750	4 600	....	....	....	....
		90 no load ...	3 900	4 200	4 250	....	....	....	....
		0 loaded	28 000	30 800	32 500	....	....	....	....
6	B.....	30 no load ...	7 400	7 400	6 500	....	....	....	....
		60 no load ...	5 450	5 950	5 600	....	....	....	....
		90 no load ...	4 550	5 000	5 000	....	....	....	....
		0 loaded	29 300	33 100	34 800	....	....	....	....
6	C.....	30 no load ...	9 400	9 150	8 250	8 050	....	....	....
		60 no load ...	6 800	7 100	6 800	6 950	....	....	....
		90 no load ...	5 250	5 750	5 800	6 250	....	....	....
		0 loaded	31 000	34 600	37 000	39 800	....	....	....
4	All...	30 no load ...	8 300	8 500	7 800	7 450	7 000	....	....
		60 no load ...	6 250	6 550	6 250	6 400	6 250	....	....
		90 no load ...	4 800	5 250	5 400	5 700	5 650	....	....
		0 loaded	24 900	27 400	28 900	30 700	31 700	....	....
2	All...	30 no load ...	8 300	8 500	7 800	9 550	10 200	8 750	7 650
		60 no load ...	6 250	6 550	6 250	7 650	8 350	7 800	7 050
		90 no load ...	4 800	5 250	5 400	6 500	7 200	7 150	6 150
		0 loaded	20 800	22 300	23 000	26 250	28 300	29 300	29 000
1	All...	30 no load ...	8 550	8 200	7 700	9 650	10 800	10 050	9 000
		60 no load ...	6 050	6 300	6 250	7 650	8 700	8 700	8 150
		90 no load ...	4 650	5 000	5 250	6 500	7 400	7 700	7 500
		0 loaded	18 600	20 000	20 800	23 700	26 050	26 000	28 000
0	All...	30 no load ...	8 600	8 350	8 050	9 950	11 200	11 000	10 350
		60 no load ...	6 150	6 350	6 450	8 000	9 100	9 400	9 250
		90 no load ...	4 700	5 150	5 400	6 600	7 650	8 200	8 200
		0 loaded	17 650	18 500	19 000	22 100	24 300	24 500	26 500
00	All...	30 no load ...	8 450	8 200	8 000	9 800	11 300	11 550	11 150
		60 no load ...	6 000	6 250	6 450	7 900	9 250	9 750	9 850
		90 no load ...	4 550	5 000	5 450	6 500	7 700	8 500	8 750
		0 loaded	16 300	17 100	17 700	20 250	22 550	24 200	25 100
0000	All...	30 no load ...	8 150	8 000	8 500	9 850	11 200	13 650	14 600
		60 no load ...	5 800	6 050	6 600	7 900	9 250	11 350	12 450
		90 no load ...	4 400	4 850	5 500	6 500	7 700	9 550	10 550
		0 loaded	14 650	15 000	15 800	17 900	19 950	23 200	25 250

[a] Correspond to the tensions of Table 19.

TABLE 22—Continued

MEDIUM LOADING DISTRICTS [a]

Size A.W.G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²
8	C.....	30 no load ...	7 600	7 600	6 850	....	....	....	....
		60 no load ...	5 800	6 200	5 900	....	....	....	....
		90 no load ...	4 700	5 250	5 300	....	....	....	....
		15 loaded. ..	28 200	30 700	33 250	....	....	....	....
6	A.....	30 no load ...	7 200	7 200	6 500	....	....	....	....
		60 no load ...	5 500	5 850	5 600	....	....	....	....
		90 no load ...	4 500	4 950	5 000	....	....	....	....
		15 loaded	22 050	24 500	25 700	....	....	....	....
6	B.....	30 no load ...	9 500	9 200	8 300	8 250	....	....	....
		60 no load ...	6 850	7 150	6 850	6 950	....	....	....
		90 no load ...	5 250	5 850	5 800	6 200	....	....	....
		15 loaded	24 500	26 200	27 800	29 500	....	....	....
6	C.....	30 no load ...	11 350	11 350	10 500	10 150	....	....	....
		60 no load ...	8 250	8 500	8 300	8 400	....	....	....
		90 no load ...	6 050	6 650	6 900	7 150	....	....	....
		15 loaded	25 100	27 600	29 500	31 350	....	....	....
4	All...	30 no load ...	10 700	10 400	9 700	8 800	9 150	....	....
		60 no load ...	7 500	7 800	7 700	7 600	7 700	....	....
		90 no load ...	5 500	6 150	6 350	6 500	6 750	....	....
		15 loaded	20 500	22 300	23 500	24 500	25 900	....	....
2	All...	30 no load ...	10 700	10 400	9 700	10 100	11 500	10 750	9 900
		60 no load ...	7 500	7 800	7 650	8 500	9 400	9 350	8 950
		90 no load ...	5 500	6 150	6 350	6 800	7 900	8 250	8 200
		15 loaded	17 450	18 600	19 200	20 900	22 800	24 000	24 300
1	All...	30 no load ...	10 150	10 250	9 400	11 350	12 400	13 650	12 600
		60 no load ...	7 200	7 500	7 400	8 850	9 950	11 500	10 850
		90 no load ...	5 250	5 900	6 000	7 300	8 200	9 750	9 600
		15 loaded	15 900	16 900	17 100	19 750	21 200	24 400	24 500
0	All...	30 no load ...	10 500	10 250	9 500	11 400	13 400	15 250	14 300
		60 no load ...	7 300	7 600	7 500	8 500	10 800	12 700	12 250
		90 no load ...	5 300	5 850	6 100	7 300	8 850	10 600	10 750
		15 loaded. ...	15 100	15 750	15 900	18 200	20 600	23 450	23 600
00	All...	30 no load ...	10 150	10 250	9 400	11 550	13 800	16 500	15 900
		60 no load ...	7 200	7 500	7 400	9 150	11 050	13 500	13 450
		90 no load ...	5 250	5 900	6 000	7 500	9 100	11 300	11 650
		15 loaded	14 200	14 750	14 500	17 150	19 550	23 000	23 400
0000	All...	30 no load ...	10 100	9 900	9 150	11 700	14 550	18 300	18 800
		60 no load ...	6 950	7 150	7 150	9 250	11 450	14 850	15 500
		90 no load ...	5 050	5 550	5 800	7 450	9 250	12 100	13 250
		15 loaded	13 100	14 200	12 700	15 600	18 500	22 300	23 650

[a] Correspond to the tensions of Table 19.

TABLE 22—Continued

LIGHT LOADING DISTRICTS[a]

Size A.W.G. No.	Grade of construction	Conditions of load and temperature	Stresses for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.
		°F	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}	Lbs./in.^{2}
8	C.....	30 no load ...	9 950	9 500	8 750	8 750	....	....	....
		60 no load ...	7 200	7 500	7 200	7 400	....	....	....
		90 no load ...	5 650	6 150	6 150	6 500	....	....	....
		30 loaded	22 800	25 200	26 900	28 800	....	....	....
6	A.....	30 no load ...	9 500	9 200	8 300	8 250	....	....	....
		60 no load ...	6 800	7 200	6 850	7 000	....	....	....
		90 no load ...	5 250	5 800	5 800	6 200	....	....	....
		30 loaded	18 150	19 750	20 700	22 000	....	....	....
6	B.....	30 no load ...	11 950	11 250	10 550	10 200	10 150	....	....
		60 no load ...	8 200	8 500	8 400	8 350	8 600	....	....
		90 no load ...	6 350	6 700	6 900	7 100	7 500	....	....
		30 loaded	19 750	21 400	22 500	23 800	25 450	....	....
6	C.....	30 no load ...	14 200	14 200	13 200	13 050	12 450	....	....
		60 no load ...	10 300	10 650	10 200	10 450	10 250	....	....
		90 no load ...	7 450	8 100	8 200	8 650	8 700	....	....
		30 loaded	21 100	23 200	24 300	26 000	27 050	....	....
4	All...	30 no load ...	13 200	13 050	12 000	11 850	11 500	....	....
		60 no load ...	9 400	9 750	9 350	9 500	9 450	....	....
		90 no load ...	6 600	7 300	6 850	7 750	8 000	....	....
		30 loaded	17 500	18 900	19 500	20 500	21 000	....	....
2	All...	30 no load ...	13 200	13 050	12 000	13 200	14 250	16 700	15 100
		60 no load ...	9 400	9 750	9 350	10 300	11 450	13 800	12 950
		90 no load ...	6 600	7 300	6 850	8 300	9 350	11 550	11 250
		30 loaded	15 450	16 200	16 100	17 750	19 350	22 550	22 550
1	All...	30 no load ...	12 800	12 800	12 000	13 600	15 300	17 550	17 100
		60 no load ...	9 100	9 450	9 050	10 600	12 000	14 550	14 450
		90 no load ...	6 300	7 000	7 150	8 500	9 750	12 100	12 250
		30 loaded	14 600	15 050	14 800	16 900	18 750	21 750	22 300
0	All...	30 no load ...	12 950	12 800	11 900	13 550	16 000	18 750	19 550
		60 no load ...	9 200	9 500	9 050	10 700	12 750	15 250	16 400
		90 no load ...	6 450	7 100	7 150	8 500	10 300	12 700	14 000
		30 loaded	14 000	14 250	13 900	15 750	18 200	21 000	22 600
00	All...	30 no load ...	12 800	12 800	11 750	13 900	16 350	19 500	20 700
		60 no load ...	9 100	9 450	9 000	10 950	13 000	15 900	17 300
		90 no load ...	6 300	7 000	7 050	8 650	10 400	12 950	14 750
		30 loaded	13 550	13 650	13 000	15 250	17 500	20 800	22 450
0000	All...	30 no load ...	12 850	12 500	11 550	14 500	16 650	21 050	23 000
		60 no load ...	8 650	9 050	8 700	11 100	13 000	17 250	19 300
		90 no load ...	6 250	6 700	6 850	8 700	10 400	14 100	16 150
		30 loaded	13 300	13 100	12 450	15 250	17 400	22 000	24 750

[a] Correspond to the tensions of Table 19.

TABLE 23.—Stresses in Soft-Drawn Covered Copper Wire for Different Span Lengths

HEAVY LOADING DISTRICTS [a]

Size A. W. G. No.	Grade of construction	Condition of load and temperature	Stresses for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.
		°F	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²
6	C	30 no load	4 700	4 550	4 250	....	....
		60 no load	3 950	4 100	3 900	....	....
		90 no load	3 400	3 700	3 650	....	....
		0 loaded	26 250	28 550	29 500	....	....
4	A	30 no load	4 350	4 250	3 850	....	....
		60 no load	3 600	3 750	3 550	....	....
		90 no load	3 150	3 450	3 300	....	....
		0 loaded	20 400	21 600	22 000	....	....
4	B and C	30 no load	5 300	5 100	4 750	....	....
		60 no load	4 200	4 400	4 300	....	....
		90 no load	3 550	3 900	3 900	....	....
		0 loaded	21 850	23 500	24 300	....	....
2	A	30 no load	5 300	5 100	4 750	4 700	....
		60 no load	4 200	4 400	4 300	4 300	....
		90 no load	3 550	3 850	3 900	4 000	....
		0 loaded	17 300	18 500	18 650	19 800	....
2	B and C	30 no load	6 650	6 700	6 000	5 700	5 500
		60 no load	5 050	5 350	5 150	5 150	5 000
		90 no load	4 050	4 500	4 550	4 700	4 700
		0 loaded	18 750	20 300	20 800	21 500	21 750
1	A	30 no load	6 500	6 500	5 800	5 550	5 300
		60 no load	4 800	5 150	4 950	4 950	4 850
		90 no load	3 900	4 400	4 400	4 500	4 500
		0 loaded	17 050	18 400	18 550	18 850	18 950
1	B and C	30 no load	8 550	8 200	7 500	7 050	6 850
		60 no load	6 000	6 250	6 050	6 000	6 000
		90 no load	4 650	5 000	5 200	5 300	5 500
		0 loaded	18 800	20 100	20 500	21 300	21 800
0	All	30 no load	8 600	8 350	8 050	7 650	7 500
		60 no load	6 150	6 350	6 450	6 400	6 500
		90 no load	4 700	5 150	5 400	5 750	5 800
		0 loaded	17 650	18 500	19 000	19 600	20 250
00	All	30 no load	8 500	8 200	8 100	8 000	8 000
		60 no load	6 000	6 250	6 500	6 650	6 850
		90 no load	4 650	5 000	5 450	5 750	6 100
		0 loaded	16 400	17 000	17 750	18 300	19 000
0000	All	30 no load	8 150	8 100	8 350	8 700	9 250
		60 no load	5 750	6 100	6 550	7 150	7 650
		90 no load	4 400	4 850	5 450	6 000	6 550
		0 loaded	14 450	15 000	15 700	16 600	18 000

[a] Correspond to the tensions of Table 20.

TABLE 23—Continued

MEDIUM LOADING DISTRICTS [a]

Size A. W. G. No.	Grade of construction	Condition of load and temperature	Stresses for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.
		°F	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²
6	C.......	30 no load	5 750	5 850	5 150	....	....	....
		60 no load	4 600	4 800	4 650	....	....	....
		90 no load	3 900	4 250	4 250	....	....	....
		15 loaded	20 550	22 600	23 500	....	....	....
4	All......	30 no load	6 650	6 700	6 000	5 250	....	....
		60 no load	5 050	5 350	5 150	4 800	....	....
		90 no load	4 100	4 550	4 600	4 350	....	....
		15 loaded	17 500	19 150	19 650	19 550	....	....
2	All......	30 no load	8 700	8 550	7 500	7 500	7 000	....
		60 no load	6 250	6 500	6 250	6 400	6 250	....
		90 no load	4 800	5 300	5 300	5 650	5 700	....
		15 loaded	16 000	17 050	17 200	18 000	18 100	....
1	All......	30 no load	8 550	8 200	8 200	8 000	8 000	8 500
		60 no load	6 000	6 250	6 600	6 750	6 850	7 550
		90 no load	4 650	5 000	5 550	5 750	6 100	6 850
		15 loaded	14 600	15 200	16 100	16 750	17 400	19 100
0	All......	30 no load	8 600	8 350	8 650	8 800	8 900	9 750
		60 no load	6 150	6 350	6 800	7 250	7 500	8 500
		90 no load	4 700	5 150	5 700	6 150	6 500	7 550
		15 loaded	13 600	14 050	15 000	15 800	16 300	18 300
00	All......	30 no load	8 500	8 200	8 550	9 050	9 750	10 900
		60 no load	6 000	6 250	6 750	7 350	8 000	9 400
		90 no load	4 600	5 000	5 650	6 250	6 850	8 200
		15 loaded	12 650	12 900	13 700	14 800	15 700	17 800
0000	All......	30 no load	8 150	8 100	8 300	8 700	9 300	10 550
		60 no load	5 800	6 100	6 550	7 100	7 700	9 050
		90 no load	4 400	4 850	5 450	6 000	6 550	7 900
		15 loaded	11 250	11 300	11 850	12 500	13 350	15 200

LIGHT LOADING DISTRICTS [a]

6	A.......	30 no load	5 750	5 700	5 150	....	....	....
		60 no load	4 600	4 800	4 700	....	....	....
		90 no load	3 850	4 250	4 300	....	....	....
		30 loaded	15 300	16 550	17 000	....	....	....
6	B and C.	30 no load	7 250	7 300	6 450	....	....	....
		60 no load	5 500	5 900	5 650	....	....	....
		90 no load	4 450	5 000	5 000	....	....	....
		30 loaded	16 600	18 250	18 850	....	....	....
4	All......	30 no load	8 750	8 500	8 400	8 650	8 400	....
		60 no load	6 250	6 600	6 800	7 150	7 150	....
		90 no load	4 700	5 300	5 700	6 250	6 350	....
		30 loaded	14 500	15 550	16 800	17 900	18 600	....

[a] Correspond to the tensions of Table 20.

TABLE 23—Continued

LIGHT LOADING DISTRICTS—Continued

Size A. W. G. No.	Grade of construction	Condition of load and temperature	Stresses for span length of—					
			100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.
		°F	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²
2	All......	30 no load	10 700	10 500	10 350	10 500	9 950	11 400
		60 no load	7 500	7 800	7 950	8 500	8 350	9 750
		90 no load	5 500	6 050	6 500	7 000	7 150	8 500
		30 loaded	13 500	14 100	14 800	15 650	15 950	18 300
1	All......	30 no load	10 450	10 300	10 700	11 300	12 000	12 900
		60 no load	7 250	7 500	8 100	8 850	9 600	10 750
		90 no load	5 250	5 900	6 500	7 300	8 000	9 250
		30 loaded	12 350	13 000	13 950	14 950	16 000	17 900
0	All......	30 no load	10 400	10 250	10 700	11 350	12 000	13 100
		60 no load	7 300	7 600	8 300	9 000	9 750	10 900
		90 no load	5 250	5 900	6 600	7 350	8 100	9 400
		30 loaded	11 700	12 100	12 850	13 800	14 750	16 400
00	All......	30 no load	10 400	10 200	10 650	11 200	11 900	12 750
		60 no load	7 250	7 500	8 050	8 800	9 600	10 650
		90 no load	5 250	5 850	6 500	7 250	8 000	9 200
		30 loaded	11 100	11 350	12 000	12 750	13 600	14 900
0000	All......	30 no load	10 100	9 850	10 150	10 750	11 450	12 350
		60 no load	6 950	7 200	7 800	8 450	9 200	10 250
		90 no load	5 050	5 600	6 250	6 950	5 650	8 850
		30 loaded	10 600	10 650	11 150	11 850	12 650	13 850

2. Minimum Sags with Corresponding Tensions of Iron and Steel Wire

The following sags are those which will stress the conductor to nine-tenths of its elastic limit under the loading conditions specified in rule 241, for the various loading districts, heavy, medium, and light.

This method has been employed for determining steel-wire sags for the reason that steel wire is generally used in rural districts where the chance that conductors of other materials will be strung on the same supporting structures is very remote, and where long spans are used for the sake of economy. It is important, therefore, to know the minimum sags that can be used without overstressing the conductor.

When short spans are used and there is every possibility that the steel wire will be replaced with copper or that copper circuits will be strung on the same supports, it is recommended that the sags for copper wire of the same or nearest cross section be used, unless the sags specified for steel wire are the greater, in which case the latter sags should be used for both the copper and steel conductors. This construction will eliminate a ragged appearance in the line and will also assist in preventing conductors from swinging together.

Under the assumed conditions, the tension in the conductor will be as great for short spans as for long ones. The longitudinal strength of the structures for such spans must, in order to withstand these stresses, be comparable to the strength of structures for long spans. The advantage of using short spans is accordingly lost unless the sags are increased.

Since the sags for iron and steel wire have been calculated on the basis of the material being stressed to nine-tenths of the average elastic limit or 0.45 of the ultimate strength, under loaded conditions, the values for the sags and tensions given in these tables are limiting values.

A series of tables of stresses is not included since the value under loaded conditions is always that given in the preceding paragraph. The stress under other conditions can be readily computed from the table of tensions.

TABLE 24.—Sags for Extra Best Best (E. B. B.) Iron Wire for Different Span Lengths

(At 30, 60, and 90° F—wires without load)

HEAVY LOADING DISTRICTS

Size of wire	Temperature	Sags for span length of—										
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.
Steel wire gage:	°F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8	30	28.5	47.5	70.5	97	130	208	......	.....	.....	.....	.....
	60	31	48.5	71	99.5	132	209	......	.....	.....	.....	.....
	90	32.5	49.5	73	100	133	210	......	.....	.....	.....	.....
No. 6	30	18	31.5	49	68.5	94.5	150	......	.....	.....	.....	.....
	60	21	34.5	51	72	97	152	......	.....	.....	.....	.....
	90	23.5	37	54	74.5	100	155	......	.....	.....	.....	.....
No. 4	30	11	21.5	34.5	49.5	69	110	......	.....	.....	.....	.....
	60	14.5	25	37.5	53	71	112	......	.....	.....	.....	.....
	90	17.5	28.5	40.5	56	75.1	116	......	.....	.....	.....	.....
7-strand cable:												
¼-inch	30	7.3	17	30.5	46.5	64.5	109	162.5	305	.....	.....	.....
	60	10.2	21	34	50.5	68	111.5	165.5	308	.....	.....	.....
	90	13.5	24	37	53	71	116	168.5	310	.....	.....	.....
5/16-inch	30	3.8	7.2	13	22	33	61	95.5	183	300	444	.....
	60	5.1	9.9	17	26.5	38	66	100	188	304	448	.....
	90	7.4	13.5	21.5	31	42.5	70.5	105	193	308	453	.....
⅜-inch	30	3.9	7.0	11.7	19	27.5	51.5	81.5	158	258	383	534
	60	5.2	9.3	15.5	23	32.5	56.5	86.5	163	262	388	539
	90	7.1	12.5	19	27.5	37.5	61.5	91.5	168	267	393	543

TABLE 24—Continued

MEDIUM LOADING DISTRICTS

Size of wire	Temperature	Sags for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	°F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8	30	15.0	27.5	42.5	60.5	81.5	132.0	......	......	......	......
	60	18.0	30.0	45.5	63.0	84.0	134.5	......	......	......	......
	90	19.5	33.0	48.0	65.5	86.5	137.0	......	......	......	......
No. 6	30	8.3	17.0	28.0	41.5	56.5	94.0	138.5	......	......	......
	60	11.9	21.0	32.0	45.0	60.5	97.0	141.5	......	......	......
	90	15.0	24.0	35.5	48.5	63.5	100.5	145.0	......	......	......
No. 4	30	5.4	10.7	18.5	28.5	40.0	68.0	102.5	190.5	......	......
	60	8.3	15.0	23.0	33.0	44.5	72.5	107.0	195.0	......	......
	90	11.8	19.0	27.5	37.0	49.0	76.5	111.0	199.5	......	......
7-strand cable:											
¼-inch	30	4.0	7.8	14.0	23.0	35.0	63.5	99.0	189.5	......	......
	60	5.2	11.0	18.0	28.0	39.5	68.5	103.5	194.0	......	......
	90	7.7	14.0	22.5	32.5	44.0	72.5	108.0	198.5	......	......
5/16-inch	30	3.1	5.2	8.2	12.5	18.0	33.5	55.0	112.0	187	279
	60	4.1	6.8	10.6	16.0	22.5	39.5	61.5	119.0	193	286
	90	5.6	9.3	14.0	20.0	27.5	45.5	67.5	125.5	200	292
⅜-inch	30	3.4	5.6	8.5	12.0	17.0	30.0	48.0	97.5	162	243
	60	4.7	7.1	10.8	15.5	21.5	35.5	54.5	104.5	169	250
	90	5.8	9.4	14.0	19.5	25.5	41.5	61.0	111.5	176	257

LIGHT LOADING DISTRICTS

Size of wire	Temperature	100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:											
No. 8	30	6.8	14.0	24	35	49.5	82.5	......	......	......	......
	60	10.2	18.0	28	39.5	53.5	86	......	......	......	......
	90	13.5	21.5	31.5	43.5	57	90	......	......	......	......
No. 6	30	4.7	8.8	15	23	33	57	87	......	......	......
	60	7.2	12.5	19.5	28	38	62.5	92	......	......	......
	90	10.7	16.5	24	33	43	67	97	......	......	......
No. 4	30	4.0	6.8	10.9	16.5	23	41	63.0	121	......	......
	60	5.8	9.8	15.0	21.5	29	47	69.5	127.5	......	......
	90	9.1	14.0	19.5	26	35	53	75.5	133.5	......	......
7-strand cable:											
¼-inch	30	3.2	5.4	8.5	13	18.5	35	57	115.5	......	......
	60	4.2	7.0	11.1	16.5	23	41	63.5	122.5	......	......
	90	5.7	9.5	14.5	21	28	46.5	69.5	128.5	......	......
5/16-inch	30	2.9	4.6	6.8	9.6	13	22	34.5	69	117	176.5
	60	3.7	5.9	8.6	12.0	16	27	40.5	77.5	126	187
	90	4.9	7.8	11.3	15.5	21	32.5	47.5	85.5	134.5	196
⅜-inch	30	3.2	5.1	7.5	10.4	14	22.5	34	64.5	106	158
	60	4.1	6.4	9.3	13	17	27	39.5	72	115	167.5
	90	5.4	8.4	11.9	16	21	32	46	80	123.5	177

TABLE 25.—Sags for Best Best (B. B.) Iron Wires for Different Span Lengths

(At 30, 60, and 90° F—wires without load)

HEAVY LOADING DISTRICTS

Size of wire	Temperature	Sags for span length of—										
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.
Steel wire gage:	° F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8	30	23	40.5	59.5	84	112.5	181	......	......	......	......	....
	60	25	42	62	86.5	113	183	......	......	......	......	....
	90	27	43.5	63	87.5	115	184	......	......	......	......	....
No. 6	30	13	25	40	58.5	78.5	129	......	......	......	......	....
	60	16	28.5	43.5	61.5	81.5	133	......	......	......	......	....
	90	19.5	31.5	46	65	84.5	136	......	......	......	......	....
No. 4	30	7.5	16	27.5	41.5	56.5	94.5	......	......	......	......	....
	60	10.6	20	31	45	60	98	......	......	......	......	....
	90	14.5	23	34	49	63.5	102	......	......	......	......	....
7-strand cable:												
1/4-inch	30	4.8	11.4	23	37	53.5	93	141	268	......	......	....
	60	6.7	15	27	41	57	96.5	144.5	271	......	......	....
	90	9.5	19	30	44.5	61	100	148	275	......	......	....
5/16-inch	30	3.1	5.6	9.7	16.5	25.5	50.5	81.5	161	266	398	555
	60	4.0	7.4	13	21	30.5	55.5	87	166	271	403	560
	90	5.6	10.0	17	25.5	35.5	61	92	171	276	407	564
3/8-inch	30	3.3	5.6	9.1	14.5	21.5	41	67.5	136	226	339	473
	60	4.5	7.2	11.6	18	26	47	73.5	142	232	344	479
	90	5.5	9.5	15	22	31	52	79	148	238	350	484

MEDIUM LOADING DISTRICTS

Size of wire	Temperature	Sags for span length of—									
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	° F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8	30	10.3	21.5	35.0	51.0	70.0	114.0	......	......	......	....
	60	13.5	24.5	38.0	54.0	72.5	116.5	......	......	......	....
	90	17.5	27.5	50.0	57.0	75.5	120.0	......	......	......	....
No. 6	30	5.4	11.9	21.5	33.5	47.0	79.5	120.0	......	......	....
	60	8.4	16.0	26.0	37.5	51.0	83.5	124.0	......	......	....
	90	11.9	20.0	29.5	41.0	55.0	87.5	128.0	......	......	....
No. 4	30	3.9	7.6	13.5	21.5	31.5	56.5	86.5	165.5	......	....
	60	6.0	11.0	18.0	26.5	37.0	61.5	92.0	170.5	......	....
	90	9.2	15.0	22.5	31.5	41.5	66.5	96.5	175.5	......	....

TABLE 25—Continued

MEDIUM LOADING DISTRICTS—Continued

Size of wire	Temperature	Sags for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
7-strand cable:	°F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
¼-inch	30	3.2	5.7	9.9	16.5	26.0	51.5	81.5	165.0	......	....
	60	4.1	7.5	13.0	21.0	31.0	56.5	87.0	169.5	......	....
	90	5.6	10.3	17.0	25.5	36.0	61.5	92.0	174.5	......	....
5/16-inch	30	2.7	4.4	6.8	10.0	14.5	27.0	45.0	96.0	163	247
	60	3.4	5.7	8.7	12.5	18.0	32.0	52.0	103.5	170	257
	90	4.5	7.4	11.3	16.5	22.5	38.0	58.0	110.5	177	266
⅜-inch	30	3.0	4.8	7.2	10.2	14.0	25.0	39.0	82.0	140	212
	60	3.7	5.9	8.9	12.5	17.5	29.5	46.0	90.0	148	220
	90	4.8	7.7	11.3	16.0	21.5	35.0	52.5	97.0	155	228

LIGHT LOADING DISTRICTS

Size of wire	Temperature	100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:											
No. 8	30	4.7	9.6	17.5	28.0	40	69	......	......	......	....
	60	7.2	13.5	22	32.5	44.5	73.5	......	......	......	....
	90	10.7	17.5	26.5	37	49	78	......	......	......	....
No. 6	30	3.6	6.5	10.9	17.5	25.5	46.5	73	......	......	....
	60	5.3	9.4	15.5	22.5	31	52.5	78.5	......	......	....
	90	8.2	13.5	19.5	27.5	36.5	58	84	......	......	....
No. 4	30	3.2	5.4	8.4	12.5	18	32.5	52	103	......	....
	60	4.6	7.8	11.7	17	23.5	39	59	110.5	......	....
	90	7.1	11.1	16.5	22	29	45.5	65.5	117.5	......	....
7-strand cable:											
¼-inch	30	2.7	4.5	6.9	10.2	14.5	27.5	45.5	95.5	......	....
	60	3.3	5.7	8.8	13	18	32.5	52.5	103	......	....
	90	4.5	7.5	11.4	16.5	23	38.5	59	110.5	......	....
5/16-inch	30	2.5	4.1	6.0	8.4	11.1	18.5	29	58	101	154
	60	3.2	5.0	7.4	10.3	14	23	34.5	66.5	110	164
	90	4.1	6.5	9.5	13	17	28	41	75	119.5	174
⅜-inch	30	2.8	4.5	6.5	9.1	12	19.5	29	54.5	91.5	138
	60	3.5	5.5	8.0	10.9	14.5	23	34.5	62.5	100.5	148
	90	4.5	7.0	10.1	13.5	17.5	28	39.5	70	109.5	158

TABLE 26.—Sags for Ordinary Grade Steel Wires for Different Span Lengths

(At 30, 60, and 90° F—wires without load)

HEAVY LOADING DISTRICTS

Size of wire	Temperature	Sags for span length of—										
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.
Steel wire gage:	° F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8	30	21	37	55.5	79	104	168	249	......	.....	......	....
	60	23	38.5	57.5	80	105	170	251	......	.....	......	....
	90	25	40.5	59.5	82	107.5	173	251	......	.....	......	....
No. 6	30	11.4	23	37.5	54	73	122	179	......	.....	......	....
	60	15	26.5	40.5	57	76.5	123	182	......	.....	......	....
	90	18	30	44	60.5	79.5	127	185	......	.....	......	....
No. 4	30	6.4	14.5	25	38	52	83	132	......	.....	......	....
	60	9.8	18.5	29	41	56.5	91.5	134	......	.....	......	....
	90	13.5	22	33	45	60	95	138	......	.....	......	....
7-strand cable:												
1/4 inch	30	3.3	7.1	16.5	26.5	41	75.5	117	225	362	......	....
	60	4.5	9.8	21	31	45.5	79.5	121	230	366	......	....
	90	6.4	13.5	25	35.5	49.5	83.5	125	233	370	......	....
5/16 inch	30	2.6	4.6	7.7	11.5	19.5	40	68	147.5	232	348	487
	60	3.4	6.0	10.1	15	24.5	46.5	74	152	237	353	492
	90	4.6	7.0	13.5	19.5	29	52	80	156	243	359	497
3/8 inch	30	2.6	4.3	6.6	9.9	14.5	28.0	48	105	180	272	283
	60	4.4	5.3	8.3	12.5	18	33.0	55	112	187	279	390
	90	4.0	6.8	10.7	16	22.5	39.5	61	118.5	193	285	397

MEDIUM LOADING DISTRICTS

Size of wire	Temperature	Sags for span lengths of—									
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	° F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8	30	9.0	19.0	32.0	46.5	64.0	105.5	156.5	......	......	....
	60	12.5	23.0	35.0	50.0	67.0	108.5	159.5	......	......	....
	90	16.0	26.0	38.5	53.0	70.0	111.5	163.0	......	......	....
No. 6	30	4.8	10.5	19.0	30.0	42.5	73.5	111.0	205.5	......	....
	60	6.7	15.0	23.8	34.5	47.5	77.5	115.0	209.5	......	....
	90	11.4	19.0	28.0	39.0	51.5	82.0	119.0	213.5	......	....
No. 4	30	3.6	6.9	11.9	19.0	28.5	51.5	80.0	154.5	248	....
	60	5.6	10.1	15.5	24.5	34.0	57.0	85.5	158.5	253	....
	90	8.8	14.5	21.5	29.5	39.0	62.5	90.5	163.5	258	....
7-strand cable:											
1/4 inch	30	2.5	4.4	7.2	11.5	18.0	38.0	65.0	135.5	227	341
	60	3.2	5.6	9.4	15.0	23.0	44.0	71.0	141.5	232	347
	90	4.3	7.6	12.5	19.5	28.0	50.0	77.0	147.5	238	352

TABLE 26—Continued

MEDIUM LOADING DISTRICTS—Continued

Size of wire	Temperature	Sags for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
7-strand cable:	° F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
5/16 inch	30	2.4	3.9	5.8	8.4	11.8	21.5	36.5	80.5	140	214
	60	3.0	4.8	7.4	10.6	15.0	26.0	43	88.5	148	223
	90	3.9	6.4	9.7	14.0	19.0	32.5	50	96.0	156	231
3/8 inch	30	2.4	3.8	5.7	8.0	10.8	18.5	29.5	61.5	108	167
	60	2.9	4.7	6.9	9.7	13.0	22.0	34.5	69.5	117	177
	90	3.7	5.9	8.7	12.0	16.5	27.0	40.5	77.5	126	186

LIGHT LOADING DISTRICTS

Size of wire	Temperature	100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	° F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8	30	4.2	8.6	15.5	25.0	36.5	63.5	97	......	......	....
	60	5.8	12.5	20.0	30.0	41.5	68.5	102	......	......	....
	90	10.2	16.5	25.0	34.5	46	73	106.5	......	......	....
No. 6	30	3.3	5.9	9.9	15.5	23	42.5	65.5	129.5	......	....
	60	5.1	8.8	14	21	29	48.5	73	136	......	....
	90	8.0	13.0	19	26	34.5	54.5	79	142	......	....
No. 4	30	3.0	5.0	7.8	11.4	16.0	29.5	47.5	94.5	156.5	....
	60	4.4	7.2	11.1	16.0	21.5	36.5	54.5	102.5	164.5	....
	90	7.0	10.8	15.5	21.0	27.5	43	61.5	110	172	....
7-strand cable:											
1/4 inch	30	2.3	3.7	5.6	8.1	11.5	20.5	34.5	79	136	209
	60	2.8	4.6	7.0	10.1	14	25.5	41.5	85	144	217
	90	3.7	6.0	9.1	13.0	18	31	48	93	152.5	226
5/16 inch	30	2.3	3.7	5.2	7.3	9.7	16	24.5	49.5	86	132
	60	2.5	4.4	6.5	9.0	12	19.5	30	57.5	95.5	143
	90	3.6	5.7	8.3	11.5	15	24.5	35.5	63	105	154
3/8 inch	30	2.3	3.7	5.3	7.3	9.7	15.5	23	44	72	109
	60	2.8	4.4	6.4	8.8	11.6	18.5	27	50	81	120
	90	3.6	5.6	8.0	10.9	14.5	22.5	32.5	57.5	90.5	130

TABLE 27.—Sags for Siemens-Martin Steel Wires for Different Span Lengths

(At 30, 60, and 90° F—wires without load)

HEAVY LOADING DISTRICTS

Size of wire	Temperature	Sags for span length of—											
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.	1000 ft.
Steel wire gage:	°F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8	30	5.5	17	31.5	49	67	113	170	317	....	....	....	....
	60	9.1	20	34.5	51	70	113	172.5	320	....	....	....	....
	90	12.7	24	38	54	73	117	175	325	....	....	....	....
No. 6	30	3.3	7.3	16	28	43	77.5	119	230	....	....	....	....
	60	5.2	10.7	20.5	32	47.5	81.0	123	233	....	....	....	....
	90	7.7	15	25	38.5	51.5	85.5	127	238	....	....	....	....
No. 4	30	2.4	4.6	8.5	15	25	50	82	164	....	....	....	....
	60	3.5	6.5	12	20	30	55.5	86.5	168	....	....	....	....
7-strand cable:	90	5.0	9.6	16.5	25.5	35.5	61.5	91.5	173	....	....	....	....
1/4-inch	30	1.9	3.3	5.4	8.9	15	37.0	69.5	152	258	392	....	....
	60	2.2	3.4	5.7	11.4	19	43.5	74.5	158	264	397	....	....
	90	2.7	5.0	8.6	15	24	49	81	164	264	402	....	....
5/16-inch	30	1.8	3.0	4.8	6.8	9.7	19	36	89	162	252	360	....
	60	2.2	3.6	5.6	8.2	12	23.5	42.5	97.5	170	260	367	....
	90	2.7	4.5	7.9	10.4	15	29	49.5	105	177	267	374	....
3/8-inch	30	1.7	2.7	4.0	5.6	7.5	13	21.5	50	99	165	245	564
	60	1.9	3.1	4.6	6.5	8.8	15.5	25	57.5	109	175	254	574
	90	2.2	3.6	5.4	7.6	10.5	18.5	29.5	65.5	118	184	264	583

MEDIUM LOADING DISTRICTS

Size of wire	Temperature	Sags for span length of—									
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	°F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8	30	2.9	5.5	11.4	21.5	34.0	64.5	101.5	197	......	......
	60	4.1	8.1	16.0	26.5	39.0	69.5	106	201.5	......	......
	90	6.2	12.0	20.5	31.5	44.0	74	110	206	......	......
No. 6	30	2.2	4.0	6.7	11.2	18.0	39.5	67	137.5	......	......
	60	3.0	5.4	9.4	15.5	24.0	46	73	143	......	......
	90	4.4	8.0	13.5	21.0	29.7	51	79	149	......	......
No. 4	30	2.0	3.3	5.2	7.8	11.4	23	41	93	......	......
	60	2.6	4.3	6.9	10.4	15.0	29.5	49	101	......	......
7-strand cable:	90	3.6	6.1	9.5	14.5	20.5	36	56	108.5	......	......
1/4-inch	30	1.7	2.8	4.2	6.1	8.6	16.5	29.5	78	147.5	233
	60	2.0	3.2	4.9	7.3	10.3	20	35.5	86	155.5	241
	90	2.4	3.9	6.0	8.8	12.5	24.5	42.5	94	163	248
5/16-inch	30	1.7	2.8	4.1	5.7	7.7	13	21	46.5	88.5	145
	60	2.0	3.3	4.8	6.7	9.1	15.5	25	54	98	156
	90	2.5	4.0	5.9	8.2	11.2	19	30	62.5	107	166
3/8-inch	30	1.7	2.4	3.8	5.2	6.9	11.2	16.5	33	58.5	94
	60	1.9	3.0	4.3	5.9	7.9	13	19	38	65.5	104
	90	2.2	3.5	5.0	6.9	9.2	15	22.5	44	74.3	115

TABLE 27—Continued

LIGHT LOADING DISTRICTS

Size of wire	Temperature	Sags for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	°F	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
No. 8	30	2.1	3.6	5.9	9.3	14.5	31.0	54.5	117	......	......
	60	2.8	4.8	8.0	12.5	19.5	37.5	61.5	124	......	......
	90	3.9	7.0	11.4	17.5	25.0	44.5	68	130	......	......
No. 6	30	2.0	3.2	5.0	7.2	10.3	19.5	34	77.5	137	......
	60	2.6	4.2	6.5	9.6	13.5	25.5	41.5	86.5	145	......
	90	3.5	5.9	9.0	13.0	18.5	31.5	49	94.5	154	......
No. 4	30	1.9	3.0	4.5	6.3	8.5	14.5	23.5	51.5	94	......
	60	2.4	3.8	5.7	8.0	10.9	18.5	29.5	61	104	......
	90	3.2	5.2	7.7	10.8	14.5	24.0	36.5	70	114	......
7-strand cable:											
¼-inch	30	1.6	2.6	3.8	5.3	7.1	11.9	18.5	41	78	130.5
	60	1.9	3.0	4.4	6.2	8.3	14.0	22	47.5	87.5	141.5
	90	2.2	3.6	5.3	7.4	9.9	16.5	26	55.5	97.5	151.5
5/16-inch	30	1.7	2.7	3.8	5.3	7.0	11.3	17	32.5	56	88
	60	2.0	3.1	4.5	6.2	8.2	13.5	20	38	64	99
	90	2.4	3.8	5.5	7.7	9.9	16.0	23.5	44.5	72	109.5
⅜-inch	30	1.6	2.6	3.7	5.1	6.6	10.5	15.5	28	45.5	68.5
	60	1.9	2.9	4.2	5.7	7.5	11.9	17.5	31.5	51.5	83
	90	2.2	3.4	4.9	6.7	8.7	13.5	20	36	58	84.5

TABLE 28.—Tensions for Extra Best Best (E. B. B.) Iron Wire for Different Span Lengths

HEAVY LOADING DISTRICTS [a]

Size of wire	Conditions of load and temperature	Tensions for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.
Steel wire gage:	°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8	30 no load	37	36	35	34	34	34	.....	.....	.....	.....	.....
	60 no load	35	35	34	34	34	33	.....	.....	.....	.....	.....
	90 no load	34	33	33	33	33	33	.....	.....	.....	.....	.....
	0 loaded	422	422	422	422	422	422	.....	.....	.....	.....	.....
No. 6	30 no load	86	75	70	67	65	64	.....	.....	.....	.....	.....
	60 no load	72	69	66	65	64	63	.....	.....	.....	.....	.....
	90 no load	64	64	64	63	63	62	.....	.....	.....	.....	.....
	0 loaded	592	592	592	592	592	592	.....	.....	.....	.....	.....

[a] Correspond to the sags of Table 24.

14112°—21——14

TABLE 28—Continued

HEAVY LOADING DISTRICTS—Continued

Size of wire	Conditions of load and temperature	Tensions for span length of—										
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.
Steel wire gage:	°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 4........	30 no load ..	188	149	134	127	122	118	.....	.....	.....	.....	.....
	60 no load ..	144	132	123	120	118	115	.....	.....	.....	.....	.....
	90 no load ..	118	117	115	114	113	112	.....	.....	.....	.....	.....
	0 loaded...	818	818	818	818	818	818	.....	.....	.....	.....	.....
7-strand cable:												
¼ inch.....	30 no load ..	258	169	138	124	119	109	106	102	.....	.....	.....
	60 no load ..	183	141	124	116	113	106	104	101	.....	.....	.....
	90 no load ..	140	122	114	109	107	104	102	101	.....	.....	.....
	0 loaded...	810	810	810	810	810	810	810	810	.....	.....	.....
5/16 inch.....	30 no load ..	832	682	541	440	380	323	299	278	268	265	.....
	60 no load ..	611	499	413	364	332	300	285	272	265	262	.....
	90 no load ..	426	368	332	310	296	280	272	266	262	260	.....
	0 loaded...	1394	1394	1394	1394	1394	1394	1394	1394	1394	1394	.....
⅜ inch.....	30 no load ..	1134	984	849	725	642	540	492	452	437	427	422
	60 no load ..	863	747	656	592	544	491	463	438	429	422	418
	90 no load ..	625	560	523	494	475	451	438	426	421	417	415
	0 loaded...	1711	1711	1711	1711	1711	1711	1711	1711	1711	1711	1711

MEDIUM LOADING DISTRICTS[a]

Size of wire	Conditions of load and temperature	Tensions for span length of—									
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8..........	30 no load	70	59	55	53	52	50	.....	.....	.....	.....
	60 no load	58	54	52	51	50	49	.....	.....	.....	.....
	90 no load	53	50	49	49	48	48	.....	.....	.....	.....
	15 loaded	422	422	422	422	422	422	.....	.....	.....	.....
No. 6.........	30 no load	176	134	117	108	103	98	96	.....	.....	.....
	60 no load	123	110	103	100	97	95	94	.....	.....	.....
	90 no load	96	95	93	93	92	92	92	.....	.....	.....
	15 loaded......	592	592	592	592	592	592	592	.....	.....	.....
No. 4..........	30 no load	372	293	244	217	201	185	177	171	.....	.....
	60 no load	242	212	196	187	180	174	170	167	.....	.....
	90 no load	170	167	165	165	165	164	164	163	.....	.....
	15 loaded......	818	818	818	818	818	818	818	818	.....	.....

[a] Correspond to the sags of Table 24.

TABLE 28—Continued

MEDIUM LOADING DISTRICTS—Continued

Size of wire	Conditions of load and temperature	Tensions for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
7-strand cable:	°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
¼ inch........	30 no load	474	375	301	249	215	185	172	161	.....	.....
	60 no load	347	266	234	206	190	172	164	157	.....	.....
	90 no load	243	210	190	178	171	162	158	154	.....	.....
	15 loaded......	810	810	810	810	810	810	810	810	.....	.....
5/16 inch........	30 no load	1011	942	864	784	706	590	517	451	424	412
	60 no load	777	721	663	610	560	499	462	426	410	403
	90 no load	563	531	502	479	459	434	420	405	397	394
	15 loaded......	1394	1394	1394	1394	1394	1394	1394	1394	1394	1394
⅜ inch........	30 no load	1297	1238	1174	1114	1034	915	827	730	686	663
	60 no load	1016	971	925	883	835	777	730	681	657	644
	90 no load	756	736	717	700	689	668	655	639	630	626
	15 loaded......	1711	1711	1171	1711	1711	1711	1711	1711	1711	1711

LIGHT LOADING DISTRICTS[a]

Steel wire gage:											
No. 8..........	30 no load	153	116	98	90	85	79	.....	.....	.....	.....
	60 no load	102	90	84	81	78	76	.....	.....	.....	.....
	90 no load	76	75	74	74	73	73	.....	.....	.....	.....
	30 loaded......	422	422	422	422	422	422	.....	.....	.....	.....
No. 6..........	30 no load	312	260	219	193	177	160	152	.....	.....	.....
	60 no load	203	182	168	159	153	147	144	.....	.....	.....
	90 no load	137	137	137	137	137	137	137	.....	.....	.....
	30 loaded......	592	592	592	592	592	592	592	.....	.....	.....
No. 4..........	30 no load	505	462	416	377	347	308	287	267	.....	.....
	60 no load	338	318	300	288	279	267	260	253	.....	.....
	90 no load	221	226	229	233	234	238	240	241	.....	.....
	30 loaded......	818	818	818	818	818	818	818	818	.....	.....
7-strand cable:											
¼ inch........	30 no load	586	544	497	449	404	336	297	260	.....	.....
	60 no load	450	417	382	351	324	287	267	247	.....	.....
	90 no load	327	308	290	277	268	252	244	235	.....	.....
	30 loaded......	810	810	810	810	810	810	810	810	.....	.....
5/16 inch........	30 no load	1095	1070	1038	1003	966	892	826	729	675	645
	60 no load	858	840	819	792	774	733	697	654	627	611
	90 no load	646	630	624	617	613	607	599	592	587	582
	30 loaded......	1394	1394	1394	1394	1394	1394	1394	1394	1394	1394
⅜ inch........	30 no load	1372	1355	1334	1308	1282	1231	1176	1101	1047	1012
	60 no load	1087	1079	1070	1057	1048	1024	1010	983	966	954
	90 no load	821	828	836	841	846	864	871	888	898	904
	30 loaded......	1711	1711	1711	1711	1711	1711	1711	1711	1711	1711

[a] Correspond to the sags of Table 24.

TABLE 29.—Tensions for Best Best (B. B.) Iron Wire for Different Span Lengths

HEAVY LOADING DISTRICTS [a]

Size of wire	Conditions of load and temperature	Tensions for span length of—										
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.
Steel wire gage:	° F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8	30 no load	46	42	41	40	39	38	.....	.....	.....	.....	.....
	60 no load	43	41	40	39	39	38	.....	.....	.....	.....	.....
	90 no load	40	39	38	38	38	38	.....	.....	.....	.....	.....
	0 loaded	474	474	474	474	474	474	.....	.....	.....	.....	.....
No. 6	30 no load	114	93	84	80	77	73	.....	.....	.....	.....	.....
	60 no load	92	83	78	75	74	72	.....	.....	.....	.....	.....
	90 no load	79	76	74	73	72	72	.....	.....	.....	.....	.....
	0 loaded	665	665	665	665	665	665	.....	.....	.....	.....	.....
No. 4	30 no load	275	200	168	154	147	137	.....	.....	.....	.....	.....
	60 no load	193	166	149	142	138	133	.....	.....	.....	.....	.....
	90 no load	146	138	134	132	129	128	.....	.....	.....	.....	.....
	0 loaded	915	915	915	915	915	915	.....	.....	.....	.....	.....
7-strand cable:												
¼-inch	30 no load	396	257	185	155	141	127	121	115	.....	.....	.....
	60 no load	281	195	158	141	132	122	118	114	.....	.....	.....
	90 no load	197	156	139	129	125	119	115	113	.....	.....	.....
	0 loaded	900	900	900	900	900	900	900	900	.....	.....	.....
5/16-inch	30 no load	1015	876	731	593	494	392	349	315	301	294	290
	60 no load	779	661	552	465	412	354	328	305	296	290	288
	90 no load	564	482	422	381	354	324	310	297	291	287	286
	0 loaded	1530	1530	1530	1530	1530	1530	1530	1530	1530	1530	1530
⅜-inch	30 no load	1354	1229	1090	950	831	673	591	521	494	481	472
	60 no load	1070	963	854	757	687	593	544	501	483	473	468
	90 no load	804	729	660	615	576	531	506	482	472	466	463
	0, loaded	1891	1891	1891	1891	1891	1891	1891	1891	1891	1891	1891

MEDIUM LOADING DISTRICTS [a]

Size of wire	Conditions of load and temperature	Tensions for span length of—									
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	° F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8	30 no load	101	76	67	63	60	58	.....	.....	.....	.....
	60 no load	76	66	62	59	58	56	.....	.....	.....	.....
	90 no load	62	59	57	56	56	55	.....	.....	.....	.....
	15 loaded	474	474	474	474	474	474	.....	.....	.....	.....
No. 6	30 no load	268	192	153	134	125	115	110	.....	.....	.....
	60 no load	174	143	127	119	115	110	107	.....	.....	.....
	90 no load	122	115	111	108	107	105	104	.....	.....	.....
	15 loaded	665	665	665	665	665	665	665	.....	.....	.....

[a] Correspond to the sags of Table 25.

TABLE 29—Continued

MEDIUM LOADING DISTRICTS—Continued

Size of wire	Conditions of load and temperature	Tensions for span length of—									
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	° F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 4..........	30 no load.....	504	413	337	285	254	223	209	196	.....	.....
	60 no load.....	335	284	248	231	218	204	197	190	.....	.....
	90 no load.....	219	207	200	196	193	189	188	185	.....	.....
	15 loaded......	915	915	915	915	915	915	915	915	.....	.....
7-strand cable:											
¼-inch.......	30 no load.....	596	509	425	345	289	229	208	184		
	60 no load.....	460	389	322	271	241	207	195	179	.....	.....
	90 no load.....	334	284	248	224	208	190	185	174	.....	.....
	15 loaded......	900	900	900	900	900	900	900	900	.....	.....
$\frac{5}{16}$-inch.......	30 no load.....	1167	1110	1040	962	883	734	633	527	486	463
	60 no load.....	928	870	818	759	702	612	549	489	465	447
	90 no load.....	699	663	624	590	557	522	488	459	447	432
	15 loaded......	1530	1530	1530	1530	1530	1530	1530	1530	1530	1530
⅜-inch.......	30 no load.....	1494	1444	1386	1321	1253	1117	1013	864	793	756
	60 no load.....	1205	1163	1118	1069	1022	934	870	791	751	728
	90 no load.....	929	901	876	851	823	793	763	730	714	703
	15 loaded......	1891	1891	1891	1891	1891	1891	1891	1891	1891	1891
LIGHT LOADING DISTRICTS [a]											
Steel wire gage:											
No. 8..........	30 no load.....	224	169	133	114	104	94	.....	.....	.....	.....
	60 no load.....	145	120	106	98	94	89	.....	.....	.....	.....
	90 no load.....	98	92	89	87	85	84	.....	.....	.....	.....
	30 loaded......	474	474	474	474	474	474	.....	.....	.....	.....
No. 6..........	30 no load.....	404	352	301	259	229	197	181	.....	.....	.....
	60 no load.....	274	242	217	200	188	175	168	.....	.....	.....
	90 no load.....	178	171	166	163	161	158	157	.....	.....	.....
	30 loaded......	665	665	665	665	665	665	665	.....	.....	.....
No. 4..........	30 no load.....	626	580	534	487	447	385	348	312	.....	.....
	60 no load.....	437	408	383	360	344	321	307	292	.....	.....
	90 no load.....	283	281	278	278	278	276	276	275	.....	.....
	30 loaded......	915	915	915	915	915	915	915	915	.....	.....
7-strand cable:											
¼-inch.......	30 no load.....	686	650	609	564	517	431	370	315	.....	.....
	60 no load.....	548	516	481	446	413	358	322	292	.....	.....
	90 no load.....	415	392	369	348	330	303	287	274	.....	.....
	30 loaded......	900	900	900	900	900	900	900	900	.....	.....
$\frac{5}{16}$-inch.......	30 no load.....	1237	1215	1190	1158	1132	1052	980	869	783	736
	60 no load.....	996	981	959	936	914	863	822	757	717	692
	90 no load.....	768	755	746	735	728	707	694	675	662	654
	30 loaded......	1530	1530	1530	1530	1530	1530	1530	1530	1530	1530
⅜-inch.......	30 no load.....	1563	1546	1523	1502	1478	1428	1372	1292	1212	1159
	60 no load.....	1271	1258	1247	1234	1220	1195	1166	1136	1105	1081
	90 no load.....	989	989	990	993	994	994	1000	1011	1014	1014
	30 loaded......	1891	1891	1891	1891	1891	1891	1891	1891	1891	1891

[a] Correspond to the sags of Table 25.

TABLE 30.—Tensions for Ordinary Grade Steel Wire for Different Span Lengths

HEAVY LOADING DISTRICTS [a]

Size of wire	Conditions of load and temperature	Tensions for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.
Steel wire gage:	°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8	30 no load	52	46	43	43	42	41	40	.....	.....	.....	.....
	60 no load	46	43	42	41	41	40	40	.....	.....	.....	.....
	90 no load	42	42	41	40	40	40	39	.....	.....	.....	.....
	0 loaded	508	508	508	508	508	508	508	.....	.....	.....	.....
No. 6	30 no load	132	103	92	87	84	80	77	.....	.....	.....	.....
	60 no load	100	89	84	80	79	77	76	.....	.....	.....	.....
	90 no load	83	80	78	77	76	76	75	.....	.....	.....	.....
	0 loaded	712	712	712	712	712	712	712	.....	.....	.....	.....
No. 4	30 no load	318	225	186	169	158	148	143	.....	.....	.....	.....
	60 no load	211	176	162	153	147	142	139	.....	.....	.....	.....
	90 no load	153	147	143	139	138	136	134	.....	.....	.....	.....
	0 loaded	982	982	982	982	982	982	982	.....	.....	.....	.....
7-strand cable:												
¼-inch	30 no load	566	415	285	216	183	156	145	136	134	.....	.....
	60 no load	419	298	222	185	166	148	140	134	133	.....	.....
	90 no load	291	218	181	162	152	141	136	132	131	.....	.....
	0 loaded	1034	1034	1034	1034	1034	1034	1034	1034	1034	.....	.....
5/16-inch	30 no load	1192	1070	924	782	649	491	416	363	345	333	328
	60 no load	931	819	698	596	514	426	384	350	336	328	325
	90 no load	729	610	518	462	422	380	356	339	329	323	322
	0 loaded	1710	1710	1710	1710	1710	1710	1710	1710	1710	1710	1710
⅜-inch	30 no load	1726	1630	1506	1372	1238	990	829	677	619	592	577
	60 no load	1402	1316	1203	1093	992	830	728	635	597	579	567
	90 no load	1088	1017	931	857	792	705	652	600	576	566	558
	0 loaded	2249	2249	2249	2249	2249	2249	2249	2249	2249	2249	2249

MEDIUM LOADING DISTRICTS [a]

Size of wire	Conditions of load and temperature	Tensions for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8	30 no load	109	85	74	69	65	62	61	.....	.....	.....
	60 no load	83	72	67	64	62	61	60	.....	.....	.....
	90 no load	66	63	61	60	60	59	59	.....	.....	.....
	15 loaded	508	508	508	508	508	508	508	.....	.....	.....
No. 6	30 no load	301	217	171	148	137	125	119	116	.....	.....
	60 no load	216	155	138	129	124	118	115	113	.....	.....
	90 no load	128	121	118	115	114	112	111	111	.....	.....
	15 loaded	712	712	712	712	712	712	712	712	.....	.....

[a] Correspond to the sags of Table 26.

TABLE 30—Continued

MEDIUM LOADING DISTRICTS—Continued

Size of wire	Conditions of load and temperature	Tensions for span length of— 100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 4	30 no load	553	462	379	320	282	245	227	209	205	.....
	60 no load	359	309	273	250	236	220	212	204	201	.....
	90 no load	227	218	211	208	205	202	200	198	197	.....
	15 loaded	982	982	982	982	982	982	982	982	982	.....
7-strand cable:											
¼-inch	30 no load	740	669	584	497	416	309	260	223	209	202
	60 no load	584	520	448	381	329	266	238	213	204	199
	90 no load	438	385	335	291	267	236	220	205	200	196
	15 loaded	1034	1034	1034	1034	1034	1034	1034	1034	1034	1034
5/16-inch	30 no load	1334	1278	1213	1147	1067	914	778	629	563	532
	60 no load	1066	1017	961	906	844	734	658	572	532	512
	90 no load	806	773	731	696	659	606	566	526	505	495
	15 loaded	1710	1710	1710	1710	1710	1710	1710	1710	1710	1710
⅜-inch	30 no load	1842	1798	1751	1696	1635	1503	1370	1155	1027	956
	60 no load	1515	1478	1439	1392	1346	1247	1152	1022	948	905
	90 no load	1197	1172	1143	1110	1084	1022	982	917	881	860
	15 loaded	2249	2249	2249	2249	2249	2249	2249	2249	2249	2249

LIGHT LOADING DISTRICTS[a]

Size of wire	Conditions of load and temperature	100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:											
No. 8	30 no load	247	190	150	127	115	102	97	.....	.....	.....
	60 no load	157	129	114	106	101	95	93	.....	.....	.....
	90 no load	102	98	94	92	91	90	89	.....	.....	.....
	30 loaded	508	508	508	508	508	508	508	.....	.....	.....
No. 6	30 no load	437	385	332	287	254	215	197	181	.....	.....
	60 no load	290	259	233	215	202	188	180	173	.....	.....
	90 no load	182	178	174	172	170	168	167	166	.....	.....
	30 loaded	712	712	712	712	712	712	712	712	.....	.....
No. 4	30 no load	670	627	582	535	495	424	382	340	322	.....
	60 no load	459	433	409	387	371	345	330	314	307	.....
	90 no load	289	290	291	291	292	292	293	293	293	.....
	30 loaded	982	982	982	982	982	982	982	982	982	.....
7-strand cable:											
¼-inch	30 no load	819	787	751	710	665	572	491	390	346	325
	60 no load	662	634	602	567	532	463	405	353	326	312
	90 no load	510	489	464	441	417	379	353	324	309	301
	30 loaded	1034	1034	1034	1034	1034	1034	1034	1034	1034	1034
5/16-inch	30 no load	1399	1379	1355	1327	1295	1227	1155	1021	920	857
	60 no load	1135	1115	1095	1075	1051	1004	957	879	826	793
	90 no load	868	858	851	837	829	812	794	767	750	739
	30 loaded	1710	1710	1710	1710	1710	1710	1710	1710	1710	1710
⅜-inch	30 no load	1893	1880	1863	1848	1827	1780	1735	1619	1534	1458
	60 no load	1564	1555	1545	1536	1523	1491	1471	1410	1367	1331
	90 no load	1245	1243	1242	1242	1240	1237	1234	1233	1227	1225
	30 loaded	2249	2249	2249	2249	2249	2249	2249	2249	2249	2249

[a] Correspond to the sags of Table 26.

TABLE 31.—Tensions for Siemens-Martin Steel Wire for Different Span Lengths

HEAVY LOADING DISTRICTS [a]

Size of wire	Conditions of load and temperature	Tensions for span length of—											
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.	1000 ft.
Steel wire gage:	° F	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs
No. 8	30 no load	189	99	76	67	63	60	58	56	....	....	....	....
	60 no load	119	81	69	64	61	58	57	56	....	....	....	....
	90 no load	84	70	63	61	59	57	56	55	....	....	....	....
	0 loaded	694	694	694	694	694	694	694	694	....	....	....	....
No. 6	30 no load	452	310	219	166	147	126	118	111	....	....	....	....
	60 no load	279	211	168	143	131	119	113	109	....	....	....	....
	90 no load	204	160	138	125	120	113	110	107	....	....	....	....
	0 loaded	966	966	966	966	966	966	966	966	....	....	....	....
No. 4	30 no load	835	686	536	417	342	261	230	207	....	....	....	....
	60 no load	598	478	387	322	281	239	213	201	....	....	....	....
	90 no load	410	337	287	250	232	213	203	193	....	....	....	....
	0 loaded	1347	1347	1347	1347	1347	1347	1347	1347	....	....	....	....
7-strand cable:													
1/4 inch	30 no load	1003	895	779	641	505	315	244	199	184	177	....	....
	60 no load	845	740	628	505	396	272	226	192	181	175	....	....
	90 no load	689	590	488	389	314	249	210	186	178	173	....	....
	0 loaded	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	....	....
5/16 inch	30 no load	1730	1650	1546	1430	1300	1030	794	567	488	454	436	....
	60 no load	1458	1378	1280	1172	1058	832	666	520	466	442	428	....
	90 no load	1189	1113	1025	931	830	675	573	483	447	430	421	....
	0 loaded	2160	2160	2160	2160	2160	2160	2160	2160	2160	2160	2160	....
3/8 inch	30 no load	2652	2566	2495	2419	2315	2109	1868	1411	1114	967	891	801
	60 no load	2292	2235	2166	2097	2006	1805	1596	1231	1019	915	859	788
	90 no load	1964	1907	1844	1778	1696	1517	1368	1083	941	870	829	776
	0 loaded	3061	3061	3061	3061	3061	3061	3061	3061	3061	3061	3061	3061

MEDIUM LOADING DISTRICTS [a]

Size of wire	Conditions of load and temperature	Tensions for span length of—									
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	° F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 8	30 no load	361	295	206	149	122	101	93	86	.....	.....
	60 no load	253	199	147	119	107	94	89	84	.....	.....
	90 no load	169	135	113	101	95	88	86	82	.....	.....
	15 loaded	694	694	694	694	694	694	694	694	.....	.....
No. 6	30 no load	653	576	487	397	320	232	197	171	.....	.....
	60 no load	490	420	350	287	244	199	180	164	.....	.....
	90 no load	337	285	244	215	196	177	167	158	.....	.....
	15 loaded	966	966	966	966	966	966	966	966	.....	.....

[a] Correspond to the sags of Table 27.

TABLE 31—Continued

MEDIUM LOADING DISTRICTS—Continued

Size of wire	Conditions of load and temperature	Tensions for span length of—									
		100 ft.	125 ft.	150 ft.	175 ft.	200 ft.	250 ft.	300 ft.	400 ft.	500 ft.	600 ft.
Steel wire gage:	°F	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
No. 4..........	30 no load.....	1005	944	871	790	705	546	438	345	.....	.....
	60 no load.....	777	721	658	592	527	428	370	319	.....	.....
	90 no load.....	559	514	476	428	394	347	322	297	.....	.....
	15 loaded......	1347	1347	1347	1347	1347	1347	1347	1347	.....	.....
7-strand cable:											
1/4 inch........	30 no load.....	1108	1064	1010	943	876	719	568	386	320	292
	60 no load.....	950	908	856	791	728	592	474	350	304	283
	90 no load.....	794	752	704	656	588	479	398	321	289	275
	15 loaded......	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350
5/16 inch........	30 no load.....	1819	1780	1738	1691	1630	1510	1361	1080	891	783
	60 no load.....	1546	1508	1473	1434	1388	1264	1139	932	807	730
	90 no load.....	1274	1240	1209	1176	1125	1036	938	807	737	686
	15 loaded......	2160	2160	2160	2160	2160	2160	2160	2160	2160	2160
3/8 inch........	30 no load.....	2687	2660	2637	2606	2564	2476	2375	2139	1895	1689
	60 no load.....	2354	2331	2307	2279	2241	2162	2068	1869	1683	1525
	90 no load.....	2024	2002	1982	1957	1925	1859	1781	1620	1492	1388
	15 loaded......	3061	3061	3061	3061	3061	3061	3061	3061	3061	3061

LIGHT LOADING DISTRICTS[a]

Steel wire gage:											
No. 8..........	30 no load.....	493	449	399	344	290	210	172	143	.....	.....
	60 no load.....	377	337	293	251	216	173	152	135	.....	.....
	90 no load.....	265	234	206	183	166	147	137	129	.....	.....
	30 loaded......	694	694	694	694	694	694	694	694	.....	.....
No. 6..........	30 no load.....	741	702	661	617	568	470	388	301	267	.....
	60 no load.....	574	541	505	467	430	364	318	271	251	.....
	90 no load.....	414	389	363	340	319	288	268	248	238	.....
	30 loaded......	966	966	966	966	966	966	966	966	966	.....
No. 4..........	30 no load.....	1069	1044	1014	980	941	855	768	621	536	.....
	60 no load.....	842	820	794	765	734	670	612	527	482	.....
	90 no load.....	620	605	587	569	551	519	491	457	440	.....
	30 loaded......	1347	1347	1347	1347	1347	1347	1347	1347	1347	.....
7-strand cable:											
1/4 inch........	30 no load.....	1156	1137	1112	1085	1058	989	906	738	602	519
	60 no load.....	996	980	956	931	904	843	769	633	535	479
	90 no load.....	839	823	801	778	755	702	642	540	483	446
	30 loaded......	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350
5/16 inch........	30 no load.....	1860	1847	1830	1812	1788	1737	1678	1546	1407	1286
	60 no load.....	1586	1575	1562	1545	1525	1483	1435	1328	1231	1151
	90 no load.....	1314	1305	1295	1283	1276	1238	1205	1138	1092	1036
	30 loaded......	2160	2160	2160	2160	2160	2160	2160	2160	2160	2160
3/8 inch........	30 no load.....	2717	2706	2695	2685	2673	2644	2606	2524	2432	2331
	60 no load.....	2384	2375	2365	2359	2349	2326	2296	2235	2155	2090
	90 no load.....	2050	2047	2041	2037	2030	2015	1993	1956	1915	1878
	30 loaded......	3061	3061	3061	3061	3061	3061	3061	3061	3061	3061

[a] Correspond to the sags of Table 27.

3. Mechanical Data for Copper and Steel Wire

(*a*) *Copper Wire.*—The following table contains data on the ultimate strength and per cent of elongation before failure of hard, medium, and soft copper wire as given in the 1915 report of the American Society for Testing Materials.

The elastic limit as given by the same Society is 55 to 60 per cent of the ultimate strength for hard-drawn copper and 50 to 55 per cent for medium-drawn copper. There is no definite elastic limit for soft copper, but its behavior, after having a slight preliminary stretch, may be considered as approximately that of an elastic material having a limit of elasticity of 10 000 to 15 000 pounds per square inch.

The modulus of elasticity has been taken at 16 000 000 for all grades of copper. The coefficient of linear thermal expansion per degree F has been taken as 0.96×10^{-5}.

TABLE 32.—Mechanical Data for Copper Wire

Size A. W. G.	Diameter	Hard-drawn: Average ultimate strength	Hard-drawn: Average elongation	Medium-drawn: Average minimum ultimate strength	Medium-drawn: Average maximum ultimate strength	Medium-drawn: Elongation	Soft-drawn: Average ultimate strength	Soft-drawn: Average elongation
	Inches	Lbs./in.²	Per cent	Lbs./in.²	Lbs./in.²	Per cent	Lbs./in.²	Per cent
No. 8	0.128	63 700	1.06	49 660	56 660	1.08		
No. 6	.162	62 100	1.14	49 000	56 000	1.15		
No. 4	.204	60 100	1.24	48 330	55 330	1.25	37 000	30
No. 2	.258	57 600	1.98	47 000	54 000	2.50		
No. 1	.289	56 100	2.17	46 000	53 000	2.75		
No. 0	.325	54 500	2.40	45 000	52 000	3.00		
No. 00	.365	52 800	2.80	44 000	51 000	3.25	36 000	35
No. 000	.41	51 000	3.25	43 000	50 000	3.60		
No. 0000	.46	49 000	3.75	42 000	49 000	3.75		

(*b*) *Iron and Steel Wire and Cables.*—The following table contains data on the strength of various grades of iron and steel wire and cables. The data for cables was obtained from tests made by the American Telephone and Telegraph Co. and by the Bureau of Standards, and for solid wire from manufacturers' tables.

The elastic limit for different samples of the same grade of wire will vary over a considerable range, the minimum value being 0.45 of the ultimate strength and the maximum 0.55 of the ultimate. The average elastic limit, therefore, has been taken as one-half of the ultimate strength.

However, in order that the minimum value of elastic limit may not be exceeded in practice, the sags for iron and steel wire were all figured on the basis of a maximum stress of nine-tenths of the average elastic limit under the most extreme loading condition.

The coefficient of linear expansion for iron and steel per degree F has been taken as 0.67×10^{-5}.

TABLE 33.—Mechanical Data for Iron and Steel Wires and Cables

Size, nominal	Actual diameter	Area	Ultimate strength of—				Modulus of elasticity $\times 10^6$ of—	
			EBB iron	BB iron	Ordinary grade steel	Siemens-Martin steel	EBB and BB	Ordinary grade and Siemens-Martin
Solid:	Inches	Sq. in.	Lbs./in.²	Lbs./in.²	Lbs./in.²	Lbs./in.²		
No. 8, Stl. W. G.	0.165	0.0214	45 450	51 000	54 700	74 800	26	29
No. 6, Stl. W. G.	.203	.0324	45 450	51 000	54 600	74 000	26	29
No. 4, Stl. W. G.	.238	.0445	45 500	51 000	54 600	75 000	26	29
Stranded:								
¼ in., 7-83 mils	.249	.0379	47 500	52 700	60 700	79 200	19	21
5/16 in., 7-109 mils	.327	.0654	47 400	52 000	58 100	73 400	19	21
⅜ in., 7-120 mils	.36	.0792	48 000	53 000	63 200	85 900	19	21

4. Resultant Conductor Loadings

The following table gives the resultant loading in pounds per foot for conductors of various size and material in regions of heavy, medium, and light loading. The calculations are based on the assumed loadings given in rule 241 and on average values of the diameters of weatherproof wires. The over-all diameters of covered wires supplied by various manufacturers vary considerably and hence average values are chosen. This is also true of the sizes of the strands which make up stranded steel cables. The values of loading are based on the sizes of strands given in the table.

TABLE 34.—Calculated Loading for Conductors of Various Sizes

Size of conductor	Diameter over all	Weight of conductor	Resultant loading for region of— Heavy loading	Medium loading=2/3 heavy	Light loading=4/9 heavy
Bare solid copper, A. W. G.:	In.	Lbs. per ft.	Lbs. per ft.	Lbs. per ft.	Lbs. per ft.
No. 12	0.081	0.020	0.816	0.544	0.363
No. 10	.102	.032	.839	.559	.373
No. 8	.128	.050	.872	.582	.3875
No. 6	.162	.0795	.917	.611	.407
No. 4	.204	.126	.981	.655	.435
No. 2	.258	.201	1.075	.717	.477
No. 1	.289	.253	1.137	.757	.505
No. 0	.325	.320	1.214	.809	.539
No. 00	.365	.403	1.309	.873	.583
No. 0000	.460	.641	1.575	1.050	[a].801
T. B. W. P. solid copper, A. W. G.:					
No. 12	.21	.035	.937	.625	.417
No. 10	.25	.053	.982	.655	.437
No. 8	.26	.075	1.003	.670	.447
No. 6	.32	.112	1.075	.717	.478
No. 4	.38	.164	1.164	.777	.518
No. 2	.44	.260	1.278	.858	.567
No. 1	.47	.316	1.345	.897	.597
No. 0	.50	.407	1.435	.958	.638
No. 00	.53	.502	1.532	1.022	.682
No. 0000	.65	.767	1.850	1.235	[a].960
T. B. W. P. stranded copper, A. W. G.:					
No. 2	.444	.270	1.285	.855	.572
No. 1	.518	.328	1.395	.928	.620
No. 0	.620	.424	1.557	1.038	693
No. 00	.662	.522	1.666	1.110	.740
No. 0000	.785	.800	1.993	1.330	[a] 1.000
250 000 cir. mils	.862	.985	2.217	1.475	[a] 1.230
350 000 cir. mils	.978	1.345	2.619	1.742	[a] 1.680
500 000 cir. mils	1.108	1.894	3.217	[a] 2.370	[a] 2.370
750 000 cir. mils	1.343	2.822	4.272	[a] 3.530	[a] 3.530
1000 000 cir. mils	1.531	3.674	5.230	[a] 4.590	[a] 4.590
Bare stranded aluminum, A. W. G.:					
No. 2	.291	.061	1.023	.682	.455
No. 1	.328	.077	1.065	.710	.474
No. 0	.368	.097	1.112	.741	.494
No. 00	.414	.122	1.168	.780	.518
No. 0000	.522	.195	1.312	.875	.584
Bare steel—solid and stranded:					
No. 8-Stl. W. G. solid	.162	.069	.912	.608	.405
No. 6-Stl. W. G. solid	.192	.097	.953	.635	.423
No. 4-Stl. W. G. solid	.225	.134	1.006	.671	.447
1/4 in.-7-83 mils stranded	.249	.125	1.022	.681	.454
5/16 in.-7-109 mils stranded	.327	.210	1.142	.761	.508
3/8 in.-7-120 mils stranded	.360	.295	1.230	.820	.547
Bare solid copper No. 8 B. W. G	.165	.082	.921	.614	.410
Bare solid iron No. 12 B. W. G	.109	.032	.846	.564	.376
Bare solid iron No. 14 B. W. G	.083	.019	.816	.544	.363
Bare solid copper No. 12 N. B. S	.104	.033	.842	.561	.374
Bare solid copper No. 14 N. B. S	.080	.019	.814	.543	.362

[a] These values are 25 per cent greater than the weight of the conductor. (See rule 241.)

5. District Loading Map

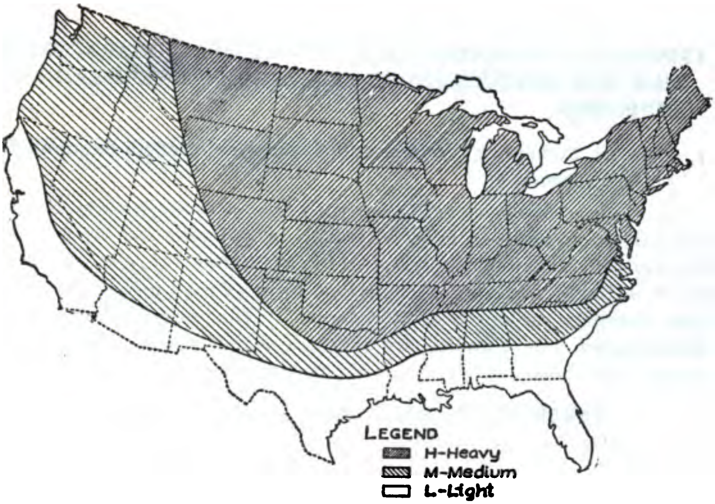

FIG. 1.—*District loading map, showing territorial division of the United States with respect to loading on overhead lines*

APPENDIX B. LOADING DATA, MECHANICAL CHARACTERISTICS, AND RECOMMENDED SETTINGS OF OVERHEAD LINE SUPPORTS

1. Data for Computing Vertical and Transverse Strength Required for Line Supports

(*a*) *Assumed Vertical and Transverse Loads on Conductors of Various Materials and Sizes.*—The vertical loads on supports due to the conductors with or without ice based on the assumptions of rule 242 (*a*), are given in Table 35. Values for vertical loadings for wires of other sizes and materials can be readily computed. The over-all diameters of weatherproof wire supplied by different manufacturers vary considerably, and hence average values are chosen for the table.

TABLE 35.—Vertical Loads on Conductor Supports

Size of conductor	Diameter over all	Weight of—		
		Conductor +0.5 inch of ice=heavy	Conductor +0.25 inch of ice=medium	Conductor only=light
Bare solid copper, A. W. G.:	In.	Lbs. per ft.	Lbs. per ft.	Lbs. per ft.
No. 12	0.081	0.381	0.123	0.020
No. 10	.102	.406	.141	.032
No. 8	.128	.440	.167	.050
No. 6	.162	.491	.207	.079
No. 4	.204	.564	.267	.126
No. 2	.258	.673	.360	.201
No. 1	.289	.744	.420	.253
No. 0	.325	.833	.499	.320
No. 00	.365	.940	.594	.403
No. 0000	.460	1.238	.861	.641
T. B. W. P. solid copper, A. W. G.:				
No. 12	.21	.476	.178	.035
No. 10	.25	.519	.208	.053
No. 8	.26	.547	.234	.075
No. 6	.32	.621	.289	.112
No. 4	.38	.711	.360	.164
No. 2	.44	.843	.474	.260
No. 1	.47	.919	.540	.316
No. 0	.50	1.029	.640	.407
No. 00	.53	1.143	.745	.502
No. 0000	.65	1.482	1.047	.767

TABLE 35—Continued

Size of conductor	Diameter over all	Weight of— Conductor +0.5 inch of ice=heavy	Conductor +0.25 inch of ice=medium	Conductor only=light
T. B. W. P. stranded copper, A. W. G.:	In.	Lbs. per ft.	Lbs. per ft.	Lbs. per ft.
No. 2	0.444	0.855	0.486	0.270
No. 1	.518	.961	.567	.328
No. 0	.620	1.120	.694	.424
No. 00	.662	1.245	.806	.522
No. 0000	.785	1.599	1.122	.800
250 000 cir. mils	.862	1.832	1.331	.985
350 000 cir. mils	.978	2.264	1.728	1.345
500 000 cir. mils	1.108	2.894	2.316	1.894
750 000 cir mils	1.343	3.969	3.318	2.822
1 000 000 cir. mils	1.531	4.937	4.227	3.674
Bare stranded aluminum, A. W. G.:				
No. 2	.291	.553	.229	.061
No. 1	.328	.592	.257	.077
No. 0	.368	.636	.289	.097
No. 00	.414	.691	.328	.122
No. 0000	.522	.831	.436	.195
Bare steel—solid and stranded:				
No. 8 Stl. W. G.—solid	.162	.481	.197	.069
No. 6 Stl. W. G.—Solid	.192	.527	.236	.097
No. 4 Stl. W. G.—Solid	.225	.587	.282	.134
¼-in.—7-83 mils—stranded	.249	.590	.280	.125
5/16-in.—7-109 mils—stranded	.327	.725	.390	.210
⅜-in.—7-120 mils—stranded	.360	.830	.485	.295
Bare solid copper No. 8 B. W. G	.165	.495	.211	.082
Bare solid iron No. 12 B. W. G	.109	.410	.144	.032
Bare solid iron No. 14 B. W. G	.083	.381	.123	.019
Bare solid copper No. 12 N. B. S	.104	.409	.143	.033
Bare solid copper No. 14 N. B. S	.080	.380	.122	.019

The values of transverse loads computed from rules 240 (*b*), 242 (*b*), and 281 for various grades of construction (A, B, C, D, or E) and for the different loading districts (H, M, or L) are given in Table 36.

These values are computed on the assumption that a definite fiber stress, equal to half the ultimate strength of the material, will be considered as a limiting value, and that the loading specified in rules 242 and 281 for grades B and D in heavy loading districts will be modified to apply to the other grades and districts. Thus the column headed "AM, BH, DH" is computed for an 8-pound wind and a half-inch of ice on conductors. The next column to the right gives values two-thirds as great, and the same ratio is applied to each succeeding column. The column headed AH gives values 50 per cent larger than for BH. It must be remembered that for signal poles not guyed, double strength is called for, and this is most easily figured by simply doubling the quantity given for the loading district concerned, rather than to introduce different working stresses in the material.

Values for transverse loadings for wires of other outside diameters can be readily computed by adding 1 inch to the outside diameter in inches, which will give the force in column AH. This results because one must divide by 12 to convert to feet, multiply by 8 to give values for BH and increase these by one-half for AH.

TABLE 36.—Equivalent Transverse Force on Wires

Actual force on ice-covered wire modified for grade and for loading district
(Pounds per conductor per foot)

Size of conductor	AH	AM BH DH	AL BM CH DM EH	BL CM DL EM	CL EL
Bare solid, A. W. G.:					
No. 12	1.08	0.721	0.480	0.320	0.214
No. 10	1.10	.735	.490	.327	.218
No. 8	1.13	.752	.501	.334	.223
No. 6	1.16	.775	.516	.344	.230
No. 4	1.20	.803	.535	.357	.238
No. 2	1.26	.839	.559	.373	.248
No. 1	1.29	.859	.573	.382	.255
No. 0	1.33	.883	.589	.393	.262
No. 00	1.37	.910	.607	.404	.270
No. 0000	1.46	.973	.649	.433	.288
T. B. W. P. solid, A. W. G.:					
No. 12	1.21	.807	.538	.359	.239
No. 10	1.25	.833	.556	.370	.247
No. 8	1.26	.840	.560	.373	.249
No. 6	1.32	.880	.587	.391	.261
No. 4	1.38	.920	.613	.409	.273
No. 2	1.44	.960	.640	.427	.284
No. 1	1.47	.980	.653	.436	.290
No. 0	1.50	1.000	.667	.444	.296
No. 00	1.53	1.020	.680	.453	.302
No. 0000	1.65	1.100	.733	.489	.326
T. B. W. P. stranded, A. W. G.:					
No. 2	1.44	.963	.642	.428	.285
No. 1	1.52	1.012	.675	.450	.300
No. 0	1.62	1.080	.720	.480	.320
No. 00	1.66	1.108	.739	.492	.328
No. 0000	1.79	1.190	.793	.529	.353
250 000 cir. mils	1.86	1.241	.828	.552	.368
350 000 cir. mils	1.98	1.319	.879	.586	.391
500 000 cir. mils	2.11	1.405	.937	.625	.416
750 000 cir. mils	2.34	1.58	1.041	.694	.463
1 000 000 cir. mils	2.53	1.69	1.125	.750	.500

TABLE 36—Continued

Size of conductor	AH	AM BH DH	AL BM CH DM EH	BL CM DL EM	CL EL
Bare stranded, A. W. G.:					
No. 2	1.29	0.861	0.574	0.383	0.255
No. 1	1.33	.885	.590	.393	.262
No. 0	1.38	.917	.611	.407	.272
No. 00	1.41	.943	.628	.419	.279
No. 0000	1.52	1.015	.676	.451	.301
Bare—solid and stranded:					
No. 8—Stl. W. G.—solid	1.162	.773	.516	.344	.229
No. 6—Stl. W. G.—solid	1.192	.794	.530	.353	.235
No. 4—Stl. W. G.—solid	1.225	.816	.544	.363	.242
¼ in.-7-83 mils—stranded	1.249	.833	.555	.370	.247
5/16 in.-7-109 mils—stranded	1.327	.884	.590	.393	.262
⅜ in.-7-120 mils—stranded	1.360	.906	.604	.403	.269
Bare solid, No. 8, B. W. G	1.17	.777	.518	.345	.230
Bare solid, No. 12, B. W. G	1.11	.739	.493	.329	.219
Bare solid, No. 14, B. W. G	1.08	.722	.481	.321	.214
Bare solid, No. 12, N. B. S	1.10	.736	.491	.327	.218
Bare solid, No. 14, N. B. S	1.08	.720	.480	.320	.213

(*b*) *Calculation of Moments of Resistance of Poles.*—The resisting moments of sound chestnut, western red cedar, and cypress poles for varying ground-line circumferences given in Table 37 are based on a maximum allowable fiber stress of 2500 pounds per square inch, which is one-half of the assumed ultimate strength.

The resisting moments of northern white cedar and redwood poles are based upon an allowable fiber stress of 1800 pounds per square inch, which is one-half of the assumed ultimate strength.

For other varieties of wood poles, the resisting moments will be in the same proportion to those tabulated as the relative ultimate strengths of the different woods.

For sound southern yellow pine, the same values as for chestnut may be used. Values 30 per cent greater than for chestnut may be used for dense southern yellow pine meeting the standard of the American Society for Testing Materials. Southern yellow pine should not be used for supporting structures unless creosoted or subjected to some other preservative treatment, as otherwise the rapid deterioration will require early replacement.

The following formula has been used in calculating the moments:

M=0.0002638 f C^3=moment in pound-feet; where

f=allowable fiber stress in pounds per square inch, and

C=circumference of the pole at ground line in inches.

While the ground-line section may not be the most stressed section in poles with considerable taper, it is so regarded here. Since the wood usually deteriorates most rapidly at this point, it is here that sufficient strength must be provided.

TABLE 37.—Resisting Moments of Sound Wood Poles for Various Ground-Line Circumferences, Based on a Maximum Allowable Fiber Stress of 2500 Pounds per Square Inch for Chestnut, Western Red Cedar, and Cypress, and 1800 Pounds per Square Inch for Northern White Cedar and Redwood

Circumference at ground in inches	Resisting moments for fiber stress of— 2500 lbs./in.²	Resisting moments for fiber stress of— 1800 lbs./in.²	Circumference at ground in inches	Resisting moments for fiber stress of— 2500 lbs./in.²	Resisting moments for fiber stress of— 1800 lbs./in.²
	Lb. ft.	Lb. ft.		Lb. ft.	Lb. ft.
24	9 120	6 560	50	82 400	59 400
25	10 300	7 420	51	87 500	63 000
26	11 600	8 350	52	92 700	66 800
27	13 000	9 350	53	98 200	70 700
28	14 500	10 400	54	103 800	74 800
29	16 100	11 600	55	109 700	79 000
30	17 800	12 800	56	115 800	83 400
31	19 650	14 150	57	122 100	87 900
32	21 600	15 600	58	128 700	92 650
33	23 700	17 100	59	135 400	97 750
34	25 900	18 700	60	142 500	102 600
35	28 300	20 400	61	149 700	107 800
36	30 800	22 150	62	157 200	113 200
37	33 400	24 050	63	164 900	118 700
38	36 200	26 100	64	172 900	124 500
39	39 100	28 200	65	181 100	130 400
40	42 200	30 400	66	189 600	136 500
41	45 450	32 700	67	198 400	142 800
42	48 900	35 200	68	207 400	149 300
43	52 400	37 750	69	216 700	156 000
44	56 200	40 450	70	226 200	162 900
45	60 100	43 300	71	236 000	170 000
46	64 200	46 200	72	246 200	177 300
47	68 500	49 300	73	256 600	184 800
48	72 900	52 500	74	267 200	192 400
49	77 600	55 900	75	278 200	200 300

2. Method for Determining Size of Wood Pole Required

(*a*) *Formula Used.*—Given the span length, the size, material, number, and height of conductors, the size of pole which will fulfill the requirements of rules 240 (*b*), 242 (*b*), and 281 may be obtained by use of the following formulas for any transverse strength requirement as determined by hazards involved and climatic conditions imposed:

Let n_1 to n_n=Numbers of conductors in groups, all conductors in a group being of the same outside diameter and at the same elevation.

N=Total number of conductors.

P_1 to P_n=Equivalent transverse forces in pounds per foot of span for the sizes of conductors in the respective groups, as taken from Table 36.

h_1 to h_n=Respective elevations above ground, in feet, of conductors subjected to forces P_1 to P_n.

S=Span length, in feet (or one-half the sum of the adjacent spans).

P_0=Pressure in pounds per square foot as given in the rules mentioned above, according to local conditions (A, B, C, D, or E and H, M, or L).

D=Estimated mean diameter of pole, in feet.

H=Height of pole, above ground, in feet.

Then the moment due to the pressure on the pole is $M_p=1/2\ P_0DH^2$ pound-feet, the moment due to the pressure on the conductors is $M_c=S\ (P_1n_1h_1+P_2n_2h_2+\ .\ .\ .\ +P_nn_nh_n)$ pound-feet, and the total bending moment on the pole is $M=M_p+M_c$. This value of M will always be employed for poles carrying supply lines only, but where only signal conductors are concerned the bending moment to be considered in order to fulfill the requirements of rule 281 will be as follows, when side guys are to be used:

$M=M_p+M_c$, when N is not greater than 10;

$M=M_p+\frac{10}{N}M_c$, when N is 11, 12, 13, or 14; or

$M=M_p+\frac{2}{3}M_c$, when N is not less than 15.

When it is intended to use a pole strong enough to allow the omission of side guys, the bending moment to be considered will be $M=2(M_p+M_c)$, $M=2(M_p+\frac{10}{N}M_c)$, or $M=2(M_p+\frac{2}{3}M_c)$, according to the value of N.

A pole should then be selected having a length equal to H plus the depth to which it is set in the ground, and a ground-line circumference giving, by Table 37, a resisting moment equal to, or greater than, M as obtained from the above formulas.

(*b*) *Examples*.—(1) Suppose it is desired to choose a pole to comply with the rules under the following conditions:

Adjacent spans, 61.66 feet and 89 feet; average span 75.33 feet.

Height of pole above ground 62 feet.

Line in urban heavy loading territory, and carrying the following wire load:

Height of arm above ground in feet	Size of wire	Kind of wire	Number of wires	Voltage (or other class)
60.33	6 A. W. G	T. B. W. P. solid copper	6	7.6 amp.
58.33	6 A. W. G	do	6	7.6 amp.
56.33	6 A. W. G	do	6	7.6 amp.
54.33	0000 A. W. G	do	4	2300 volts
52.33	0000 A. W. G	do	4	2300 volts
50.33	0000 A. W. G	do	6	2300 volts
48.33	00 A. W. G	do	2	2300 volts
44.33	350 000 c. m.	do	4	2300 volts
44.33	6 A. W. G	do	1	7.6 amp.
42.33	6 A. W. G	do	2	110 volts

According to rule 231 (*b*), this pole will be required to comply with grade C and the transverse loading due to the wires will be computed as follows, the values of "Force per foot" being taken from column CH of Table 36:

Span length in feet		Force in pounds per foot		Number of wires		Height above ground in feet		Bending moment (pound-feet)
75.33	×	0.587	×	6	×	60.33	=	15 960
75.33	×	.587	×	6	×	58.33	=	15 420
75.33	×	.587	×	6	×	56.33	=	14 900
75.33	×	.734	×	4	×	54.33	=	11 980
75.33	×	.734	×	4	×	52.33	=	11 520
75.33	×	.734	×	6	×	50.33	=	16 620
75.33	×	.68	×	2	×	48.33	=	4 950
75.33	×	.88	×	4	×	44.33	=	11 720
75.33	×	.587	×	1	×	44.33	=	1 960
75.33	×	.587	×	2	×	42.33	=	3 740
							$M_o=$	108 770

Assume pole to be used will be one having an allowable fiber stress of 2500 pounds per square inch. A pole of 57 inches ground-line circumference will have a resisting moment of 122 000 pound-feet. The rules require a minimum top diameter of 6 inches, and for a pole of this size $M_p = \frac{1}{2} \times (\frac{2}{3} \times 8) \times \frac{6+(57+3.14)}{2 \times 12} \times 62^2 = 10\ 300$ pound-feet,

$M = M_p + M_e = 10\ 300 + 108\ 800 = 119\ 100$ pound-feet.

(2) Suppose it is desired to determine whether or not the pole used complies with the rules, under the following conditions:

Adjacent spans, 124.2 feet and 139.1 feet; average span, 131.65 feet.

Height of pole above ground, 43 feet.

Western red-cedar pole, of 10 inches top diameter, and 60 inches ground-line circumference.

Line crossing over railroad in heavy-loading district and carrying the following load:

Height of arm above ground in feet	Size of wire	Kind of wire	Number of wires	Voltage (or other class)
45.5	½-in	Bare stranded steel	1	Ground
42.17	0000 A. W. G	T. B. W. P. stranded copper	3	13 000 volts
39.67	0000 A. W. G	do	2	13 000 volts
37.17	0000 A. W. G	do	4	13 000 volts
32.17	6 A. W. G	do	1	6.6 amp.
32.17	2 A. W. G	do	3	2 300 volts
28.17	10 A. W. G	Bare solid copper	2	Private telegraph

According to rule 233 (*a*), this pole will be required to comply with grade A, and the transverse loading due to the wires will be computed as follows, the values of "Force per foot" being taken from column AH of Table 36:

Span length in feet		Force in pounds per foot		Number of wires		Height above ground in feet		Bending moment in pound-feet
131.65	×	1.25	×	1	×	45.5	=	7 500
131.65	×	1.78	×	3	×	42.17	=	29 600
131.65	×	1.78	×	2	×	39.67	=	18 600
131.65	×	1.78	×	4	×	37.17	=	34 800
131.65	×	1.32	×	1	×	32.17	=	5 600
131.65	×	1.44	×	3	×	32.17	=	18 300
131.65	×	1.10	×	2	×	28.17	=	8 100
						M_o	=	122 500

$$M_p = \frac{1}{2} \times (\frac{2}{3} \times 8) \times \frac{10 + \frac{60}{3.14}}{2 \times 12} \times 43^2 = 13\ 400$$

$$M = M_p + M_o = 135\ 900$$

By Table 37, the resisting moment for a ground-line circumference of 60 inches at a fiber stress of 2500 pounds per square inch is 142 500 pound-feet. Since this is greater than M, this pole is strong enough to comply with the rules.

(3) Suppose it is desired to determine whether or not the pole and side guys used comply with the rules, under the following conditions:

Adjacent spans, 104.5 feet and 115.5 feet; average span, 110 feet.

Height of pole above ground, 52 feet.

Chestnut pole of 8 inches top diameter, and 60 inches ground-line circumference.

Signal line crossing over railroad in heavy loading district, and carrying the following wire load:

Height of arm above ground in feet	Size of wire	Kind of wire	Number of wires	Voltage (or other class)
51	8 B. W. G	Bare copper	8	Signal.
49	12 N. B. S	do	10	Do.
47	12 N. B. S	do	10	Do.
45	12 N. B. S	do	10	Do.
43	12 N. B. S	do	5	Do.

According to rule 235 (*a*), this pole will be required to comply with grade D, and the transverse loading due to the wires will be computed as follows, the values of "Force per foot" being taken from column DH of Table 36:

Span length		Force in pounds per foot		Number of wires		Height above ground in feet		Bending moment in pound-feet
110	×	0.777	×	8	×	51	=	34 900
110	×	.736	×	10	×	49	=	39 700
110	×	.736	×	10	×	47	=	38 100
110	×	.736	×	10	×	45	=	36 500
110	×	.736	×	5	×	43	=	17 400
						M_e	=	166 600

$$M_p = \tfrac{1}{3} \times 8 \times \frac{8 + \frac{60}{3.14}}{2 \times 12} \times 52^2 = 12\ 200$$

Since N is greater than 15, $M = M_p + 2/3\ M_e = 12\ 200 + 111\ 065 = 123\ 265$ pound-feet, if side guys are used, or twice this value, that is, 246 530 pound-feet, if side guys are not used.

By Table 37, the resisting moment for a ground-line circumference of 60 inches and a fiber stress of 2500 pounds per square inch is 142 500 pound-feet. Since this is less than the value of *M* to be used without side guys, the guys will be required, and will be required to take the entire horizontal load.

By reference to Table 37, it will be seen that a pole slightly larger than 72 inches in ground-line circumference will be required if guys can not be installed.

Assume that guys are installed having a lead one-third of the height of attachment to the pole, or a lead of 15 feet with a height of attachment of 45 feet.

The force necessary at a height of 45 feet to produce—or to counteract—a bending moment of 123 265 pound-feet at the ground line is $\frac{123\ 265}{45}=2740$ pounds, and the equivalent force acting in the direction of the guy will be $\frac{\sqrt{15^2+45^2}}{15}\times 2740=8660$ pounds. A guy will therefore be required having a tensile strength at least equal to $2\times 8660=17\ 320$ pounds.

(4) Suppose it is desired to determine whether or not the pole used complies with the rules, under the following conditions:

Adjacent spans, 104 feet and 92 feet; average span, 98 feet.

Height of pole above ground, 48 feet.

Chestnut pole, of 9 inches top diameter, and 58.5 inches ground-line circumference.

Joint supply and signal line in heavy loading territory, and carrying the following wire load:

Height of arm above ground in feet	Size of wire	Kind of wire	Number of wires	Voltage (or other class)
47	6 A. W. G	T. B. W. P. solid copper	6	6.6 amp.
45	6 A. W. G	do	6	6.6 amp.
43	0000 A. W. G	do	3	2 300 volts
43	00 A. W. G	do	3	2 300 volts
41	2 A. W. G	do	6	2 300 volts
39	2 A. W. G	do	3	230 volts
39	6 A. W. G	do	2	6.6 amp.
35	12 N. B. S	Bare copper	10	Telephone
33	12 N. B. S	do	8	Telephone

According to rule 234 (*c*), this pole will be required to comply with grade C, and the transverse loading due to the wires will be computed as follows, the values of "Force per foot" being taken from column CH of Table 36:

	Span[11] length in feet		Force in pounds per foot		Number of wires		Height above ground in feet		Bending moment in pound-feet
	98	×	0.587	×	6	×	47	=	16 250
	98	×	.587	×	6	×	45	=	15 550
	98	×	.734	×	3	×	43	=	9 280
	98	×	.68	×	3	×	43	=	8 600
	98	×	.96	×	6	×	41	=	23 100
	98	×	.96	×	3	×	39	=	11 000
	98	×	.587	×	2	×	39	=	4 490
½ ×	98	×	.491	×	10	×	35	=	8 410
½ ×	98	×	.491	×	8	×	33	=	6 350
					Mc			=	103 030

$$M_p = \tfrac{1}{2} \times (2/3 \times 8) \times \frac{9+\frac{58.5}{3.14}}{2\times 12} \times 48^2 = 7\,070$$

$$M = M_c + M_p = 110\,100$$

By Table 37, the resisting moment for a ground-line circumference of 58.5 inches and a fiber stress of 2 500 pounds per square inch is 132 000 pound-feet (by interpolation between 58 and 59 inches). Since this is greater than M, this pole is strong enough.

3. Illustration of Allowable Number of Wires on a Given Pole, and on a Pole Supported by a Given Side Guy

(*a*) *Assumptions on which Tables 38, 39, and 40 are based.*—In Table 38 it is assumed (1) that all wire positions are filled and that cross arms are 2 feet apart; (2) that poles are set 5.5 feet in the ground; (3) that 6-pin cross arms are used unless otherwise stated; (4) that the placing of wires is begun at the top arm (wires 6 inches below the top of poles) and continues to lower cross arms until limited by strength of pole or clearance of wires above ground to a minimum of 19 feet at the support. This is assumed to be the minimum allowable clearance at the support if 18 feet clearance is to be maintained at the center of the span. (See Table 3.) Frequently a less number of cross arms is necessary where larger sags make the difference in elevation between the support and the center of the span greater than 1 foot. (See sag Tables 15, 16, 17, 24, 25, 26, and 27, Appendix A.)

[11] **Regarding last two lines see also rule 272 (*d*).**

In Tables 39 and 40 it is assumed (1) that the guys carry their loads with a factor of safety of 2; (2) that they are installed with a lead of 1 to 3; (3) that they are attached at the center of the load, this making it unnecessary to take into account the height of the pole. The wind pressure on the pole itself has not been taken into account in these tables. This will be equivalent to that on one or more wires, depending on size and height of pole, and should be deducted in each case.

(*b*) *Use of Table 38.*—The maximum number of wires which can be carried in compliance with these rules by sound chestnut, western red cedar, cypress, and southern pine poles of different ground-line circumferences and different spans for a 35-foot pole, is given in Table 38, according to the hazards involved (A, B, or C) and the loading districts considered (H, M, or L).

TABLE 38.—Allowable Number of No. 4 Solid Copper T.B. W.P. Wires to Be Carried by 35-Foot Sound Chestnut, Western Red Cedar, Cypress, and Southern Pine Poles Having Ground-Line Circumferences of from 32 to 48 Inches and Under Various Hazards (A, B, or C) and Loading (H, M, or L) (See foregoing explanatory note)

Hazard and loading	Span in feet	Number of wires to be carried by pole having ground-line circumference of—								
		32 in.	34 in.	36 in.	38 in.	40 in.	42 in.	44 in.	46 in.	48 in.
AH	100	([a])	6	7	8	10	11	13	16	18
	125	([a])	4	5	6	8	9	10	12	14
	150	([a])	4	4	5	6	7	9	10	12
	200	([a])	3	3	4	5	5	6	7	9
AM, BH	100	[a] 7	9	11	13	16	18	22	26	30
	125	[a] 6	7	9	10	12	14	17	20	23
	150	[a] 5	6	7	8	10	12	14	16	19
	200	[a] 4	4	5	6	7	9	10	12	14
AL, BM, CH	100	12	14	17	21	25	31	36	[b] 40	[b] 48
	125	9	11	14	16	20	23	28	33	36
	150	8	9	11	13	16	19	22	26	31
	200	6	7	8	10	12	14	16	19	22
BL, CM	100	19	23	29	35	[b] 40	[c] 48	[c] 48	[c] 48	[c] 48
	125	15	18	22	27	33	[b] 37	[b] 44	[c] 48	[c] 48
	150	12	15	18	22	26	31	36	[b] 41	[c] 48
	200	9	11	13	16	19	22	26	31	36
CL	100	31	36	[b] 45	[c] 48	[c] 48	[c] 48	[c] 48	[c] 48	[c] 48
	125	24	29	36	[b] 42	[c] 48	[c] 48	[c] 48	[c] 48	[c] 48
	150	19	24	29	36	[b] 40	[c] 48	[c] 48	[c] 48	[c] 48
	200	14	17	21	25	30	34	[b] 41	[c] 48	[c] 48

[a] For grade A in heavy and medium loading districts, 35-foot poles can not be used with so small a ground-line circumference, since pole top would be less than 7 inches. (See rule 244 *d*.)

[b] These numbers of wires will require 8-pin cross arms.

[c] These numbers of wires will fill all available pole space when carried on 8-pin cross arms, but will not use up the available strength of the pole. All other numbers of wires are carried by 6-pin cross arms.

The table may also be used for poles of greater height by using the ground-line circumference, but reducing the allowable number of wires, in proportion to the increase in elevation of the point of application of the load.

A taper of 2 inches per 5 linear feet is assumed in Table 38, but is used only for calculating the bending moment due to the wind pressure on the pole itself; the pole strength is based entirely upon the ground-line circumference, assuming this to be the most stressed section.

(c) *Use of Tables 39 and 40*.—The maximum number of wires which can be carried, in compliance with these rules, by poles supported by side guys of various strengths with various values of average span is given in Table 39 for supply lines (or for signal lines of grades A, B, and C), and in Table 40 for signal lines of grades D and E.

TABLE 39.—Allowable number of No. 4 solid copper T. B. W. P. wires to be carried on poles supported by side guys of various strengths under various grades of construction (A, B, or C) and loading (H, M, or L) (See foregoing explanatory note)

Grade and loading	Span length	Number of the designated wires allowed with specified numbers and strengths of side guys						
		1-4000 lb.	1-6000 lb.	1-10 000 lb.	1-16 000 lb.	2-10 000 lb.	1-10 000 lb. 1-16 000 lb.	2-16 000 lb.
	Ft.							
	75	6	9	15	24	31	40	49
AH........	100	5	7	11	18	23	30	37
	125	4	6	9	15	18	24	29
	150	3	5	8	12	15	20	24
	75	9	14	23	37	46	60	73
AM........	100	7	10	17	27	34	45	55
BH........	125	6	8	14	22	27	36	44
	150	5	7	11	18	23	30	37
AL........	75	14	21	34	55	69	89	....
BM........	100	10	15	26	41	52	67	83
CH........	125	8	12	21	33	41	54	66
	150	7	10	17	28	34	45	55
	75	21	31	52	82	....	....	....
BL........	100	15	23	39	62	77	....	....
CM........	125	12	19	31	49	62	80	99
	150	10	15	26	41	52	67	82
	75	31	46	77	....	....	....	....
CL........	100	23	35	58	93	....	....	....
	125	19	28	46	74	93	....	....
	150	15	23	39	62	77	....	....

TABLE 40.—Allowable number of No. 8 (B. W. G.) bare iron wires to be carried on poles supported by side guys of various strengths under various grades of construction (D or E) and loading (H, M, or L) (See foregoing explanatory note)

Grade and loading	Span length	Number of the designated wires allowed with specified numbers and strengths of side guys						
		1-4000 lb.	1-6000 lb.	1-10 000 lb.	1-16 000 lb.	2-10 000 lb.	1-10 000 lb. 1-16 000 lb.	2-16 000 lb.
	Ft.							
DH	75	16	24	41	65	81	....	....
	100	8	18	31	49	61	79	98
	125	7	10	24	39	49	63	78
	150	5	8	20	33	41	53	65
DM / EH	75	24	37	61	....	....	....	....
	100	18	27	46	73	92	....	....
	125	10	22	37	59	73	95	....
	150	8	18	31	49	61	79	98
DL / EM	75	37	55	....	....	....	....	....
	100	27	41	69	....	....	....	....
	125	22	33	55	88	....	....	....
	150	18	28	46	73	92	....	....
EL	75	55	83	....	....	....	....	....
	100	41	62	....	....	....	....	....
	125	33	50	83	....	....	....	....
	150	28	41	69	....	....	....	....

The blank spaces in the above tables indicate that more than 100 wires can be carried by the size and number of guys in question under the indicated conditions of hazard, loading, and span length, without exceeding one-half of the ultimate strength of the guys. Where the number of wires carried by a pole exceeds 80, it is good practice to install some of them in cable.

4. Minimum Pole Sizes and Recommended Depth of Setting

(*a*) *Minimum Pole Sizes.*—The dimensions of poles given in Tables 41, 42, and 43 are those referred to in rules 244 (*c*) and 283 (*a*) and are required under the conditions of loading specified by those rules. The dimensions are given for chestnut, western white cedar, red cedar, western cedar, Idaho cedar, and eastern or northern white cedar poles. Where other poles than these are used the dimensions required for any given grade of construction should be taken the same as poles having an equal ultimate fiber strength. Note: It is not advisable to use some kinds of poles without preservative butt treatment.

TABLE 41.—Minimum Dimensions of Chestnut Poles

Sizes Specified in Rules 244 (*c*) and 283 (*a*)

Length of pole in feet	Minimum circumference of poles [a]					
	For grade D, with more than 40 signal wires (rule 283 *a*), and for grade A supply lines (rule 244 *c*)		For grade D, with 21 to 40 signal wires (rule 283 *a*), for grade E, with more than 40 signal wires (rule 283 *a*), and for grades B and C supply lines (rule 244 *c*)		For grade D, with not more than 20 signal wires (rule 283 *a*), and for grade E with not more than 40 signal wires (rule 283 *a*)	
	Circumference		Circumference		Circumference	
	At top	At 6 feet from butt	At top	At 6 feet from butt	At top	At 6 feet from butt
	In.	In.	In.	In.	In.	In.
20	24	33	22	30	20	27
25	24	36	22	33	20	30
30	24	40	22	36	20	33
35	24	43	22	40	20	36
40	24	45	22	43	20	40
45	24	48	22	47	20	43
50	24	51	22	50	20	46
55	22	54	22	53	20	49
60	22	57	22	56	....	....
65	22	60	22	59	....	....
70	22	63	22	62	....	....
75	22	66	22	65	....	....
80	22	70	22	69	....	....
85	22	73	22	72	....	....
90	22	76	22	75	....	....

[a] These pole dimensions correspond to specifications for class A, B, and C poles, respectively, of the National Electric Light Association, American Telephone & Telegraph Co., and Western Union Telegraph Co.

TABLE 42.—Minimum Dimensions of Western White Cedar, Red Cedar, Western Cedar, and Idaho Cedar Poles

Sizes Specified in Rules 244 (*c*) and 283 (*a*).

Length of pole in feet	Minimum circumferences of poles *a*					
	For grade D, with more than 40 signal wires (rule 283*a*), and for grade A supply lines (rule 244 *c*)		For grade D, with 21 to 40 signal wires (rule 283 *a*), for grade E, with more than 40 signal wires (rule 283 *a*), and for grades B and C supply lines (rule 244 *c*)		For grade D, with not more than 20 signal wires (rule 283 *a*), and for grade E with not more than 40 signal wires (rule 283 *a*)	
	Circumference		Circumference		Circumference	
	At top	At 6 feet from butt	At top	At 6 feet from butt	At top	At 6 feet from butt
	In.	In.	In.	In.	In.	In.
20	28	30	25	28	22	26
25	28	34	25	31	22	28
30	28	37	25	34	22	30
35	28	40	25	36	22	32
40	28	43	25	38	22	34
45	28	45	25	40	22	36
50	28	47	25	42	22	38
55	28	49	25	44	22	40
60	28	52	25	46	22	41
65	28	54	25	48	22	43

a These pole dimensions correspond to specifications for class A, B, and C poles, respectively, of the National Electric Light Association, American Telephone & Telegraph Co., and Western Union Telegraph Co.

TABLE 43.—Minimum Dimensions of Eastern or Northern White Cedar Poles

Sizes Specified in Rules 244 (*c*) and 283 (*a*)

Length of pole in feet	Minimum circumference of poles *a*					
	For grade D, with more than 40 signal wires (rule 283 *a*), and for grade A supply lines (rule 244 *c*)		For grade D, with 21 to 40 signal wires (rule 283 *a*), for grade E, with more than 40 signal wires (rule 283 *a*), and for grades B and C supply lines (rule 244 *c*)		For grade D, with more not than 20 signal wires (rule 283 *a*), and for grade E with not more than 40 signal wires (rule 283 *a*)	
	Circumference		Circumference		Circumference	
	At top	At 6 feet from butt	At top	At 6 feet from butt	At top	At 6 feet from butt
	In.	In.	In.	In.	In.	In.
20	24	33	22	29	18.75	27
25	24	36	22	32	18.75	30
30	24	40	22	36	18.75	33
35	24	43	22	38	18.75	36
40	24	47	22	43	18.75	40
45	24	50	22	47	18.75	43
50	24	53	22	50	18.75	46
55	24	56	22	53	18.75	49
60	24	59	22	56	....	....

[a] These pole dimensions correspond to specifications for class A, B, and C poles, respectively, of the National Electric Light Association, American Telephone & Telegraph Co., and Western Union Telegraph Co.

(*b*) *Recommended Depth of Setting of Poles.*—The values given in Table 44 are those recommended as the depths to which poles should be set under ordinary straight-line conditions in firm soil or rocks. On corners or angles or heavy dead ends these values should be increased by at least 6 inches. (See rule 281 *a*.)

TABLE 44.—Recommended Depth of Setting of Poles—Rule 281 (*a*)

Length of pole in feet	Setting in soil	Setting in rock
	Ft.	Ft.
20	5	3
25	5	3.5
30	5.5	3.5
35	6	4
40	6	4
45	6.5	4.5
50	7	4.5
55	7	5
60	7.5	5
65	8	6
70	8	6
75	8.5	6
80	9	6.5

5. Depreciation of Wood Poles

Where a pole is required to conform to a definite grade of construction, A, B, or C, it must be maintained by being replaced or reinforced in accordance with rule 244 (*b*). The maximum allowable depreciation for grades A and B construction is one-third of the initial strength, and for grade C is one-half of the initial strength. Table 45 gives the minimum depreciated ground-line circumference and maximum allowable radial depreciation for wood poles of initial ground-line circumference from 24 to 75 inches, inclusive. These values are independent of the material of the pole.

TABLE 45.—Depreciation of Wood Poles

[Dimensions given in inches]

Ground-line circumference when installed	Minimum depreciated ground-line circumference for—		Maximum allowable radial depreciation for—	
	Grades A and B	Grade C	Grades A and B	Grade C
24	21.0	19.1	0.48	0.79
25	21.8	19.9	.50	.82
26	22.7	20.6	.52	.85
27	23.6	21.4	.54	.89
28	24.5	22.2	.56	.92
29	25.3	23.0	.58	.95
30	26.2	23.8	.60	.99
31	27.1	24.6	.62	1.02
32	28.0	25.4	.64	1.05
33	28.8	26.2	.66	1.08

TABLE 45—Continued

Ground-line circumference when installed	Minimum depreciated ground-line circumference for—		Maximum allowable radial depreciation for—	
	Grades A and B	Grade C	Grades A and B	Grade C
34	29.7	27.0	0.68	1.12
35	30.6	27.8	.70	1.15
36	31.5	28.6	.72	1.18
37	32.3	29.4	.74	1.21
38	33.2	30.2	.76	1.25
39	34.1	31.0	.78	1.28
40	34.9	31.8	.81	1.31
41	35.8	32.6	.82	1.34
42	36.7	33.3	.85	1.38
43	37.6	34.1	.87	1.41
44	38.4	34.9	.88	1.44
45	39.3	35.7	.91	1.48
46	40.2	36.5	.92	1.51
47	41.1	37.3	.95	1.54
48	41.9	38.1	.97	1.58
49	42.8	38.9	.99	1.61
50	43.7	39.7	1.01	1.64
51	44.6	40.5	1.03	1.67
52	45.4	41.3	1.05	1.71
53	46.3	42.1	1.07	1.74
54	47.2	42.9	1.09	1.77
55	48.1	43.7	1.11	1.80
56	48.9	44.5	1.13	1.84
57	49.8	45.3	1.15	1.87
58	50.7	46.0	1.17	1.90
59	51.5	46.8	1.19	1.94
60	52.4	47.6	1.21	1.97
61	53.3	48.4	1.23	2.00
62	54.2	49.2	1.25	2.03
63	55.0	50.0	1.27	2.07
64	55.9	50.8	1.29	2.10
65	56.8	51.6	1.31	2.13
66	57.7	52.4	1.33	2.17
67	58.5	53.2	1.35	2.20
68	59.4	54.0	1.37	2.23
69	60.3	54.8	1.39	2.26
70	61.2	55.6	1.41	2.30
71	62.0	56.4	1.43	2.33
72	62.9	57.2	1.45	2.36
73	63.8	58.0	1.47	2.40
74	64.7	58.7	1.49	2.43
75	65.5	59.5	1.51	2.46

PART 3. RULES FOR THE INSTALLATION AND MAINTENANCE OF ELECTRICAL UTILIZATION EQUIPMENT

CONTENTS

SEC. 30. SCOPE OF RULES AND GENERAL REQUIREMENTS

300. Scope of the Rules

(a) *Voltage Limits and Occupancies.*—The following rules apply to electrical utilization equipment between 25 and 750 volts, where accessible to other than qualified electrical operators, as in mills, factories, mercantile establishments, hotels, theaters, and other public buildings, cars and other vehicles, dwellings, and similar places. Signal equipment connected to signal lines (see definition 4) is exempted, except from rules under section 39.

(b) *Equipment of More than 750 Volts.*—Equipment and conductors of more than 750 volts, where accessible to other than qualified electrical operators, shall (in addition to complying with the rules of Part 3 for conductors of more than 300 volts) comply also with the rules for electrical supply stations, Part 1, where such rules require more than the rules of Part 3. Current-carrying parts shall be either incased in permanently grounded metal cases or conduits, or otherwise suitably guarded to prevent access (or too close approach) to such current-carrying parts by any but specially authorized persons not subject to distraction at the time by other activities.

(c) *Utilization Equipment Regarded as Supply Equipment.*—Electrical utilization equipment, however, as well as generating equipment, if inclosed in a separate room which is inaccessible to unauthorized persons, and if when in service under the control of a qualified electrical operator whose attention is not distracted by other processes, may be installed in conformity with the rules applying to electrical supply stations (Part 1) and in that case does not come under these rules.

301. Application of the Rules

(a) *Waiving of Rules.*—The rules are intended to apply to all such installations except as modified or waived by the proper administrative authority or its authorized agents. They are intended to be so modified or waived in particular cases wherever any rules are shown to involve expense not justified by the protection secured or for any other reason to be impracticable; or wherever it is shown that equivalent or safer construction can be more readily provided in other ways.

In cases of emergency, or pending decision of the adminis trator, the person responsible for the installation may decide as to modifications or waiver of any rule, subject to review by proper authority.

Other methods of construction and installation than those specified in the rules may be made as experiments to obtain information, if done where supervision can be given by the proper administrative authority.

(b) *Intent of Rules.*—The intent of the rules will be realized: (1) by applying the rules in full to all new installations, reconstruction, and extensions, except where any rule is shown to be impracticable for special reasons, or where the advantage of uniformity with existing construction is greater than the advantage of construction in compliance with the rules, providing the existing installation is reasonably safe; (2) by placing guards on existing installations or otherwise bringing them into compliance with the rules, except where the expense involved is not justifiable.

The time allowed for bringing existing installations into compliance with the rules will be determined by the proper administrative authority.

(c) *Temporary Work.*—It will sometimes be necessary to modify or waive certain of the rules in case of temporary installations or installations which are shortly to be discarded or reconstructed.

302. General Requirements and Compliance with Other Standards

(a) *Equipment to Be Made Safe.*—All electrical utilization equipment shall be of such construction and so installed and maintained as to reduce the life hazard as far as practicable.

(b) *Compliance with Underwriters' Code.*—Compliance with the requirements of the National Electrical Code of the National Board of Fire Underwriters for the installation of wiring and fittings is recommended.

(c) *Approved Materials.*—Where materials or devices are available which have been subjected to examination by some properly qualified body and found to comply with the general requirements of the National Electrical Safety Code, the National Electrical Code, and other nonconflicting accepted standards which apply for any given purpose, such materials or devices should be used in preference to others which have not been so examined regarding their suitability for the given purpose.

In order to avoid the necessity for repetition of such examinations by different examiners, frequently with inadequate facilities for such work, and to avoid the confusion which would result from conflicting reports as to the suitability of devices examined for a given purpose, it is necessary that such examinations should be made under standard conditions, and the record made generally available through promulgation by organizations properly equipped and qualified for experimental testing, inspections of the run of goods at factories, and service-value determinations, through field inspections, and whose findings are subject to appeal to the Bureau of Standards.

303. Inspections and Repairs

(*a*) *Future Inspections*.—Electrical utilization equipment shall comply with these safety rules when placed in service, and shall thereafter be inspected from time to time and, when necessary, cleaned. Defective equipment shall be put in good order or permanently disconnected. Defective wiring, where hazardous, shall be repaired or removed.

(*b*) *Repairs and Extensions*.—Repairs, extensions, and changes should be made to existing utilization equipment and conductors only by properly qualified persons.

304. Grounding

(*a*) *Grounding Method*.—All lightning-arrester grounding and all grounding of circuits, equipment, or wire runways, which is intended to be a permanent and effective protective measure shall be made in accordance with the methods specified in section 9.

(*b*) *Circuits Required to be Grounded*.—All circuits included in rule 300 (*a*) shall be permanently grounded in accordance with the rules of section 9, except that the following are not required to be grounded:

(1) Circuits on two-wire direct-current systems.

(2) Circuits entirely unexposed to leakage or induction from higher-voltage circuits, either through overhead construction or through transformers or other devices.

It is recommended, however, that all 3-wire (not delta 3-phase) circuits, even if unexposed, have their neutrals grounded; and that multiphase circuits, even if unexposed, where partly used for lighting, be so arranged and grounded that the lighting circuits have the lowest practicable voltage to ground.

(3) Circuits of more than 150 volts to ground.

(4) Electric-furnace circuits. (See rule 351.)

(*c*) *Grounding Noncurrent-Carrying Metal Parts*.—Under the hazardous conditions named below, fixed electrical utilization equipment shall have the exposed noncurrent-carrying metal parts, such as frames of motors, cranes, cars, and switchboards, cases of transformers and switches, and casings of wiring and conductors permanently grounded. (See section 9 for method, and rule 371 for portable devices.)

Exceptions.—No ground connection need be made to exposed metal frames of switchboards, motors, or lighting fixtures connected to direct-current trolley or third-rail circuits, or where accessible to qualified operators only, provided that such frames are effectively insulated from ground, and provided that the metal frames in question are so located with reference to insulating mats, floors, or platforms that persons can not readily touch the metal frames in question without standing on such mats, floors, or platforms.

No ground connection need be made to service-entrance conduits or to lengths not exceeding 25 feet of armored cable, metal raceways, or of conduit (or pipe of equivalent strength having each wire within protected with an extra covering of nonconducting flexible tubing) used for the protection of wires, if they are insulated from piping and other grounded surfaces in the building, and are out of reach from grounded surfaces. (See also rule 344 for further exception.)

Parts of machines, such as name plates, screws in wood, and similar small parts which are not liable to become alive, except under very unusual circumstances, are not considered as coming under the rule and may be left ungrounded.

The following conditions shall be considered hazardous:

(1) All locations where explosives, inflammable gas, or inflammable flyings normally exist in dangerous quantities.

(2) All cases where exposed grounded surfaces, such as metal frames of other machines, plumbing fixtures, conducting floors or walls, exist within the reach of persons when touching the metal parts under consideration. (Usually grounded surfaces within 5 feet horizontally of the parts considered and within 8 feet vertically of the floor are considered within reach.)

(3) All operation at more than 150 volts to ground, wherever equipment is located.

305. Working Spaces about Electrical Equipment

(*a*) *Adequate Space.*—Suitable working space shall be provided and maintained about all electrical utilization equipment.

(*b*) *Dimensions*.—The minimum horizontal dimension of the working space in front of live parts when necessarily exposed shall be:

(1) For parts on one side of more than 150 volts to ground and no live or grounded parts on the other side of the working space, 2.5 feet.

(2) For parts on one side of more than 150 volts to ground and live or grounded parts on the other, 4 feet.

(3) For parts on one side of less than 150 volts to ground and no live or grounded parts on the other, 1.5 feet.

(4) For parts on one side of less than 150 volts to ground and live or grounded parts on the other, 2.5 feet.

(*c*) *Clear Spaces*.—Working spaces adjacent to exposed live parts shall not be used as passageways.

(*d*) *Elevation of Equipment*.—The elevation of the equipment at least 8 feet above ordinarily accessible working platforms usually affords protection at least equivalent to that provided by the horizontal clearances of (*b*) and may be used in lieu thereof, if desired.

306. Guarding or Isolating Live Parts

(*a*) *Inclosure or Elevation*.—All ungrounded current-carrying parts of electrical utilization equipment, such as bus bars, conductors, and terminals, operating at more than 150 volts to ground and not isolated by elevation at least 8 feet above floor line shall, where practicable (for exception see par. *b*), be provided with suitable permanent inclosures or other guards arranged so as to prevent persons or conducting objects from inadvertently coming (or being brought) in contact with the parts in question, and at the same time so as to permit ready access to authorized persons for making inspections, adjustments, or repairs.

Inclosures may consist of suitable casings or suitable insulating coverings. The continuous insulating covering of conductors should be depended upon only when the circuit is grounded in accordance with section 9 or is less than 300 volts to ground and entirely unexposed to eakage or induction from higher-voltage circuits, and where in addition it is impracticable to install more suitable guards. It should be depended upon then only when the covering is not exposed to liability of mechanical injury (see rule 313 *c*), and is very substantial, thoroughly dry, and contains no noninsulating flame-proofing compound or oil-soaked rubber. It is recommended that in addition to the protection afforded by such coverings the insulating mats or platforms called for in paragraph (*b*) be used.

Where covers, casings, or barriers must at any time be removed from the otherwise exposed current-carrying parts which they guard, while these parts are alive, the covers, casings, or barriers, should be of insulating material, or so arranged that they can not readily be brought in contact with the live parts.

Mats may be of wood, held together by wood pins, or of cork matting, linoleum, or rubber. The material and construction should be suitable for the voltage concerned and for the prevailing conditions. If subject to moisture or to accumulations of conducting dust, flyings, or chips, mats should present surfaces minimizing the hazards from these sources.

(*b*) *Mats and Platforms*.—Where current-carrying parts of more than 150 volts to ground must necessarily be exposed (unguarded) within 8 feet from the floor line, all surrounding conducting floors and other noncurrent-carrying surfaces within reach shall be covered with suitable insulating platforms, mats, or other insulating devices.

The guarding of current-carrying parts will obviate the necessity for such insulating devices, and where the use of the latter is impracticable, from the nature of the location or processes carried on, guards should always be used.

(*c*) *Separation and Barriers*.—Bare parts at different potentials shall be effectively separated. Such parts in circuits of large capacity or more than 300 volts shall, unless provided with the inclosure or other guard specified in (*a*) above, be provided with suitable barriers, if otherwise they would be liable to be short-circuited by tools or other conducting objects.

307. Hazardous Locations

(*a*) *Sparking and Arcing Parts*.—In locations where explosives, inflammable gas, or inflammable flyings normally exist in dangerous quantities, all parts at which high temperature, sparking, or arcing is liable to occur shall be so inclosed as to reduce the hazard as far as practicable.

(b) *Methods of Inclosing Sparking and Arcing Parts.*—This protection should be obtained by one of the following methods:

(1) By placing in separate compartments or rooms, free from explosives, inflammable gas and inflammable vapors.

(2) By using casings of the inclosed type (ventilated, if necessary) when dust or inflammable flyings exist in dangerous quantities.

(3) By using explosion-proof casings when inflammable gases exist in dangerous quantities.

(c) *Material for Casings.*—All casings shall be nonabsorptive and noncombustible.

308. Illumination

The rules of the Industrial Lighting Code, prepared by the Illuminating Engineering Society, are recommended for all workshops or factories where electrical utilization equipment is employed.

309. Identification of Equipment

(a) *Safety by Identification.*—All electrical utilization equipment shall be suitably identified when added safety can be obtained thereby. (See also rules 312, 332, and 373.)

(b) *Types of Identification.*—The identification may be by position, color, number, name plate, label, design, or other means.

(c) *Voltage and Use.*—The voltage and intended use shall be shown wherever it will reduce the hazard or decrease the liability of error in operation.

SEC. 31. CONDUCTORS

310. Electrical Protection

(a) *Suitability and Size of Conductors.*—Conductors shall be suitable for the location, use, and voltage.

In three-wire (not three-phase) systems the neutral conductor shall have sufficient current capacity to carry the maximum current to which it may be subjected under actual loading conditions.

(*b*) *Fuses and Circuit-Breakers.*—Each conductor (except neutral conductors, ground conductors, and conductors of circuits the opening of which may cause special hazard by the interruption of service or removal of protection) shall be protected against excessive current by a suitable fuse or automatic circuit-breaker or by the design of the system.

(*c*) *Grounded conductors.*—All conductors normally grounded for the protection of persons shall be arranged without automatic circuit-breakers or fuses interrupting their continuity between the source of electrical supply and the point at which the ground conductor is attached, unless the circuit-breaker opens all conductors of the circuit with one operation.

Grounded neutral conductors in three-wire systems shall be arranged without automatic circuit-breakers or fuses interrupting their continuity, unless the circuit-breaker opens all conductors of the circuit with one operation.

In two-wire branches from three-wire circuits the conductor connected to the neutral is not for the purpose of this rule considered a grounded conductor.

Where the utilization equipment is connected to electrical supply lines, the point of connection to the service leads is considered as the source of electrical supply.

(*d*) *Switches.*—Switches shall open all conductors of the circuit by one operation except as follows:

(1) The switch need not open a grounded conductor.

(2) Single-pole switches may be used in two-wire branch circuits; on grounded circuits they shall be placed in the ungrounded conductor, except in key sockets on circuits of not more than 150 volts to ground.

(3) On three-wire systems with a grounded neutral conductor, the service switch may open either outside wire independently of the other, provided the neutral can not be opened without opening both outside wires.

(4) Where service switch, fuses, and meter are combined in a single self-contained device having no exposed wiring or live parts and with connections inaccessible to unauthorized persons, the switch may be so arranged that it does not disconnect the potential coil of the meter.

311. Mechanical and Thermal Protection

(a) *Mechanical Protection.*—Where exposed to mechanical injury, suitable casing, armor, or other means shall be employed to prevent injury or disturbance to conductors, their insulation, or supports. Conductors used as meter loops shall be substantially supported clear of objects other than their insulating supports, and separated from each other, or shall be in approved conduit or insulating casing, which will not rapidly deteriorate under service conditions.

(b) *Thermal Protection.*—Where conductors with combustible insulating coverings are closely grouped (as sometimes on the rear of switchboards or in cableways), they shall have a substantial noncombustible outer covering. Conductors in very hot locations shall have a noncombustible insulating covering.

(c) *Bare Conductors.*—Bare conductors shall be used only for low-voltage circuits or in locations where insulated conductors are not feasible, such as contact conductors, bus bars, and battery connections. Such bare conductors shall be fixed at adequate separations by the use of suitable supports. Except at the point where a permanent ground connection is made, such conductors within buildings shall be kept insulated from the ground. Bare conductors shall not be used where inflammable gases or explosives are liable to exist in large quantities. (See rules 307 and 314.)

312. Identification of Conductors

The neutral conductor of three-wire circuits and one conductor of two-wire circuits shall be so arranged as to be readily identified. This may be done by maintaining a specified relative position on open wiring, or the conductors may be tagged or otherwise suitably marked where run in conduits.

This conductor shall be run and maintained without change in polarity throughout the entire installation and connected at all fittings to marked terminals or to terminals which can be identified by their relative location to others, in order to preserve the continuity of the marking.

When the system to which the circuit is connected is a grounded system, the marked conductor shall be connected to the grounded conductor of this system.

On sockets and receptacles the marked conductor shall be connected to the outer screw shell.

313. Guarding and Isolating Conductors

(*a*) *Use of Inclosing Casings.*—For inclosing insulated conductors, approved metal conduit, waterproof insulating conduit, or metal sheathing shall be used, except that in dry places, compartments of suitable fire-resistive material, ducts, or runways may be used for conductors less than 750 volts, if containing no exposed combustible material. In damp places conduits shall be made waterproof and provided with suitable means for draining off condensation, unless the conductors contained are lead sheathed cable.

(*b*) *Elevation.*—All fixed conductors having insulating coverings and operating at more than 300 volts to ground, and bare ungrounded conductors at all voltages shall (unless guarded as required in *c* below) be so isolated by elevation (as required by rule 306 *a*) that no person can inadvertently come or bring conducting objects in contact with them.

(*c*) *Guarding Open Conductors of More than 300 Volts.*—Where open insulated conductors of more than 300 volts to ground, or open bare ungrounded conductors at any voltage (except bare wires used at high temperatures in heating devices, at voltages not more than 300 volts to ground) are necessarily brought closer to the floor than 8 feet and are accessible to unqualified persons, they shall be guarded by screens or inclosures.

Dependence should not be placed on the unprotected insulating covering as a suitable guard or inclosure for conductors near the floor line, nor where otherwise exposed to mechanical injury or rapid deterioration. Other guards should be provided to protect the insulation against mechanical injury and to secure the safety of persons who must come near the conductors.

314. Guarding in Damp or Hazardous Locations

(a) *Support of Conductors in Damp Locations.*—Conductors in damp locations or where exposed to corrosion, if not in waterproof conduit, or in waterproof metal sheaths in other suitable ducts, shall be effectively isolated and supported on insulators of a suitable type.

(b) *Conduit for Conductors in Hazardous Locations.*—Conductors in locations where inflammable gas or flyings normally exist shall be in grounded metal conduit or metal-sheathed cable. All fittings and outlets of such conduit and cable shall be electrically and mechanically continuous with the conduit or metal sheath, and the conduit shall be sealed by the use of suitable potheads or equivalent devices to prevent entrance of gases.

315. Precautions against Excessive Inductance and Eddy Currents

Supply conductors of alternating-current or direct-current circuits should not be run in separate iron conduits or on opposite sides of I beams or other iron structures or be otherwise run so as to increase abnormally the self-inductance of the circuit.

Such construction, by introducing large self-inductance in direct-current circuits, causes fuses to blow explosively; in alternating-current circuits it causes heating due to eddy currents in the metal.

316. Taping Ends and Joints

Ends and joints of insulated conductors, unless otherwise adequately guarded, shall have equal insulating covering with other portions of the conductor, and this covering shall be securely held in place.

317. Grounding or Isolating Service and Interior Conduits

Where service conduit or sheathing is electrically continuous with interior conduit or sheathing, the grounding required for conduit (by rule 304 *c*) shall be made directly to the service conduit or sheathing and shall have conductance not less than that of No. 6 copper wire.

Where grounded service conduit or sheathing is insulated from interior conduit or sheathing, its ground wire conductance need not exceed that required under section 9 for equipment ground wires.

It is frequently advisable to insulate interior conduit or sheathing from service conduit or sheathing, to prevent burnouts of small interior conduit, armored cable sheaths, or metal molding, by large currents which might flow from exterior conduit to interior conduit and water pipes.

318. Temporary Wiring

Temporary wiring and equipment, which is not in compliance with these rules, may be used, but only when under competent supervision; or protected by suitable barriers or warning signs while it or neighboring wiring is alive and accessible to any person.

SEC. 32. FUSES, CIRCUIT-BREAKERS, SWITCHES, AND CONTROLLERS

320. General Requirements for Switches

(*a*) *Accessibility, Marking, and Installation.*—All switches, fuses, and automatic circuit-breakers, controllers, starting rheostats, autostarters, and other control devices shall be readily and safely accessible to authorized persons; they shall be so located or marked when controlling circuits of more than 1320 watts, as sufficiently to indicate their function and the location and character of the equipment controlled by them and whether they are open or closed. They shall be so installed as to minimize the danger of accidental operation. Where practicable, they shall be so installed that gravity can not close them; and such switches as may close by gravity shall be provided with a proper stop block or latch to prevent accidental closing.

(b) *Switches for Special Circuits.*—Switches controlling emergency lighting circuits, elevator circuits, circuits in theaters, hospital operating rooms, and other circuits, the interruption of which might cause special hazard, shall be arranged so as to be accessible only to authorized persons.

(c) *Exit Lights.*—Exit lights and all lamps normally kept lighted in halls, corridors, and any other part of theaters and assembly halls used by the audience, except the general auditorium lighting, must be fed independently of the stage lighting, and must be controlled only from the lobby or other convenient place in front of the house.

321. Hazardous Locations

When necessary to install fuses, circuit-breakers, switches, or other control devices in locations where explosives, inflammable gas, or inflammable flyings exist, they shall be suitably protected. (See rule 307.)

322. Where Switches Are Required

(a) *Service Switches.*—Suitable switches, circuit-breakers, or equivalent devices shall be inserted in all feeder conductors connecting utilization installations to service connections from either overhead or underground lines. These switches shall be readily accessible, and as close as practicable to the point of connection with overhead or underground lines.

(b) *Circuit Switches.*—Suitable switches, circuit-breakers, or equivalent devices shall be inserted in all circuit leads (except a grounded conductor, see rule 310) to motors, transformers, storage batteries, electric furnaces, and similar utilization equipment, except between parts or pieces of apparatus intended to operate as a unit, and except that motor starters other than autostarters if they disconnect all wires of the circuit, need not be provided with a switch.

Switches installed for use on lighting and similar circuits of less than 1320 watts are not required to interrupt all conductors of the circuit.

(c) *Switches or Plugs on Portables.*—Switches or plug connectors shall be placed in all conductors at the point where temporary wiring or portable conductors are connected to the permanent wiring.

323. Character of Switches and Disconnectors

(a) *Capacity of Switches.*—Switches used otherwise than as disconnectors shall have a capacity such as to insure safe interruption, at the working voltage, of the greatest current which they will be required to carry continuously, and shall be marked with the current and voltage for which they are rated.

(b) *Capacity and Signs.*—Disconnectors shall be of suitable voltage and ampere rating for the circuit in which they are installed and shall be accessible only to properly qualified persons. They shall also be protected by signs warning against opening them while carrying current in excess of the safe opening limit.

Interlocking arrangements are desirable to prevent opening of such disconnectors under loads beyond their safe opening capacity and locking arrangements to prevent accidental opening.

(c) *Locking or Blocking.*—Means shall be provided so that switches controlling motors, storage batteries, transformers, electric furnaces, and similar utilization equipment can be locked or blocked in the open position and plainly tagged to prevent careless closing while work is being done on the equipment controlled by them, unless all live and moving parts of controlled equipment which would cause a hazard are so guarded as to render locking or blocking unnecessary.

Small-capacity snap switches, if near machines and in plain sight from all parts of the machines controlled, are exempted. Switches of any size are exempted if the installation comprises only one motor, and the switch is in plain sight from all parts of the machines operated by the motor.

Locking is recommended rather than blocking, wherever parts of the machinery driven are remote from the point of control.

(*d*) *Good Contact.*—Switches, controllers, and rheostats shall be so constructed as to make and maintain good contact. Knife switches shall maintain such alignment under service conditions that they may be closed with a single unhesitating motion.

324. Disconnection of Fuses before Handling

(*a*) *Automatic Disconnection.*—Fuses in circuits of more than 150 volts to ground shall, where accessible to others than qualified electrical attendants, be so arranged that the fuses are necessarily disconnected from all sources of electrical energy before they can be touched. Where the circuit voltage is less than 150 volts to ground, this protection is recommended.

This may be accomplished by a construction in which the fuse and its exposed current-carrying connections are accessible only when disconnected from the circuit, either by opening the fuse inclosure or by other means.

Where fuses are in locked cabinets (or otherwise made accessible only to qualified persons) sufficient protection is usually secured for all voltages if switches are provided to disconnect the fuses from all sources of electrical energy.

When switches and fuses are inclosed in metal cabinets and live terminals are accessible, greater hazard exists than if they were not so inclosed, as the live terminals are adjacent to grounded metal.

(*b*) *Switch Ahead of the Fuse.*—On circuits of less than 150 volts to ground, where fuses are not arranged so that they are necessarily disconnected from all sources of electrical energy before they can be touched, it is recommended that switches be so placed or arranged that opening them will disconnect the fuses from all sources of electrical energy, unless portable insulating appliances are provided for handling the fuses.

325. Arcing or Suddenly Moving Parts

(*a*) *Location.*—Fuses and circuit-breakers shall be so located and shielded that persons will not be burned by their operation.

(*b*) *Suddenly Moving Handles.*—Handles or levers of circuit-breakers and similar parts which may move suddenly in such a way that persons in the vicinity are liable to be injured by being struck by them shall be guarded or isolated.

326. Grounding Noncurrent-Carrying Metal Parts

Exposed noncurrent-carrying metal parts of switch and fuse cases, levers, and other similar parts to which leakage may occur from live parts shall be permanently grounded according to the provisions of rule 304.

Small parts, such as name plates and screws, which are not liable to become alive except under very unusual circumstances, are not considered as coming under the rule and may be left ungrounded.

327. Guarding Switches

(*a*) *Guard Disks and Handles.*—All manual switches, except switches less than 150 volts to ground and limited by fuses or automatic circuit-breakers to 60 amperes, shall have suitable casings or guards protecting the operator from danger of contact with current-carrying parts, or shall be provided with insulating handles and suitable insulating guard disks or shields so arranged between the handles and the live parts as to prevent the hand from slipping into contact with live parts or being burned by arcing at the switches.

(*b*) *Inclosure.*—Current-carrying parts of switches, fuses, or automatic circuit-breakers of more than 150 volts to ground shall be provided with inclosing guards, effective during ordinary operation, if accessible to other than properly qualified persons.

(c) *Platforms and Mats.*—Where switches or fuses of more than 150 volts to ground are not guarded during ordinary operation, suitable insulating floors, mats, or platforms shall be provided on which the operator must stand while handling the switches, fuses, or automatic circuit-breakers, and (unless operators invariably wear suitable insulating gloves while handling the switches) any conducting walls or machine frames within 3.5 feet shall be provided with suitable insulating guards.

The suitable guarding of live parts will obviate the necessity for such insulating floors and other devices, and where use of such devices is impracticable from the nature of the location or mechanical process carried on, guards should always be used.

(d) *Blades Dead.*—Single-throw switches shall be so connected as to have no exposed blades alive when a switch is open.

SEC. 33. SWITCHBOARDS AND PANELBOARDS

330. Accessibility and Convenient Attendance

(a) *Control Arrangement.*—Switchboards and panelboards shall have all switches so arranged that the means of control are readily accessible to the operator.

(b) *Location of Instruments.*—Instruments, relays, or other devices requiring reading or adjusting shall be so placed that work can be readily performed from the working space provided.

331. Location

Switchboards shall be so placed that the persons necessarily near the board will not be endangered by machinery or equipment located near the board. Means for adequate illumination shall be provided.

332. Arrangement and Identification

Connections, wiring, and equipment of switchboards and panelboards shall be arranged in an orderly manner and all switches, fuses, and automatic circuit-breakers shall be plainly marked, labeled, or arranged so as to afford ready means for identifying circuits or equipment supplied through them.

It is recommended that a diagram of switchboard or panelboard connections and devices be kept posted in some convenient place near such equipment.

333. Spacings, Barriers, and Covers

(*a*) *Separation of Bare Parts.*—The number of exposed bare parts of different potential on any switchboard or panel shall be as small as practicable, and these parts shall be effectively separated.

Such parts, including bus bars, should be so located or provided with such barriers or substantial insulating coverings that parts of different potential will not be accidentally short circuited by tools or other conducting objects.

(*b*) *Portable Covers or Shields.*—Switchboards shall have current-carrying parts which are ordinarily isolated or guarded, but which may occasionally require adjustment or repair while alive, so arranged that suitable portable covers or shields can be effectively placed to protect workmen from contact with any neighboring live parts.

334. Grounding Frames

Switchboard frames and metal cabinets should be permanently grounded, under the conditions and with the exceptions noted in rule 304.

335. Guarding Current-Carrying Parts

(*a*) *Inclosure of Parts at More than 150 Volts to Ground.*—No switchboard or panelboard operating at more than 150 volts to ground shall have current-carrying parts exposed within 8 feet of the floor, unless accessible only to qualified operators. Locked cabinets or other inclosures shall be provided where necessary to prevent such exposure. If the current-carrying parts are at any time exposed while alive, conducting floors about such boards shall be provided with a suitable insulating platform or mat so placed that no live parts can be inadvertently touched except by standing on the platform or mat. (See rules 306 and 327.)

(*b*) *Inclosure of Parts Less than 150 Volts.*—All switchboards and panelboards should be so arranged that current-carrying parts less than 150 volts to ground and less than 5 feet above the floor are inclosed in cabinets or screens as an effective precaution against accidental short-circuit or contact by persons in the vicinity.

(*c*) *Plug-Type Boards.*—Plug-type switchboards on constant-current systems, or if of more than 150 volts to ground, shall have no current-carrying parts exposed on face of boards, and plug connectors shall have all current-carrying parts guarded as long as they are alive.

(*d*) *Dead-Front Boards.*—Switchboards having no current-carrying parts exposed on the face (working space) are recommended for use in theaters and similar places where rapid handling is necessary and the attention must be given to signals or to other processes.

(*e*) *Theater Boards.*—Theater switchboards at any voltage, if having current-carrying parts exposed, shall be elevated or guarded by suitable railings to prevent contact with live parts by passers-by.

SEC. 34. MOTORS AND MOTOR-DRIVEN MACHINERY

340. Control Devices

(*a*) *Speed Limitation.*—Machines of the following types shall be provided with speed-limiting devices, unless the load and the mechanical connection thereto are of such a character as to safely limit the speed or unless the machine is always under the manual control of a qualified operator:

(1) Separately excited direct-current motors.

(2) Series motors.

(3) Motor-generators and converters which can be driven at excessive speed from the direct-current end as by a reversal of current or decrease in load.

The required limitation of speed may be obtained by the use of a relay, centrifugal switch, or other similar device which will cut off the supply of energy when excessive speed is attained.

(b) *Weak Field.*—Where the speed adjustment of direct-current motors is accomplsihed by varying the field resistance, and the nature of the load and the range of the field rheostat are such as to make a dangerous speed attainable and no speed-limit devices are used, the field rheostats shall be arranged with low-voltage releases or other necessary devices so that the motor can not be started or continued in operation under dangerously weakened field, except where the operation of such a low-voltage release might result in serious injury to service or apparatus.

Motors which are designed to permit operating under weakened field are not included in the above.

(c) *Wiring.*—Where speed-limiting devices or remote-control switches are electrically operated, the control circuits by which such devices are actuated shall be adequately guarded, by conduit or otherwise, against mechanical injury.

(d) *Low-Voltage Release.*—Manually controlled starters for motors shall be so designed and circuits so arranged that they return automatically to the "off" or starting position upon failure of the energy supply, except where the motors and their starting devices are, during operation, under supervision of qualified persons, and equivalent protection is otherwise provided.

341. Hazardous Locations

Motors in which sparking or arcing can occur during operation shall, when in locations where explosives or inflammable gas or inflammable flyings exist, be suitably protected as described in rules 307 and 304 (*c*).

342. Deteriorating Agencies

(*a*) *Inclosures.*—Suitable guards or inclosures shall be provided to protect exposed current-carrying parts of motors and the insulation of motor leads where installed directly under equipment or in other locations where dripping oil, excessive moisture, steam, vapors, chemicals, or similar injurious agencies exist.

(*b*) *Grounding Frames.*—The metal frames and other exposed noncurrent-carrying metal parts of equipment in these locations shall be permanently grounded. (See rule 304 *c*.)

343. Guards for Live Parts

(*a*) *Inclosure of Live Parts.*—Motors of more than 150 volts to ground, unless isolated by elevation at least 8 feet above the floor line, should be provided with permanent inclosures or other suitable guards so arranged as to prevent persons or conducting objects from inadvertently coming or being brought into contact with live parts or interfering with the operation of the motors.

(*b*) *Mats and Platforms.*—Suitable insulating mats or platforms of substantial construction and providing good footing shall be so placed on floors and, if necessary, on frames of machines having exposed live parts of more than 150 volts to ground that the operator or other persons in the vicinity can not readily touch such parts unless standing on the mats, platforms, or insulating floors.

The suitable guarding of live parts by inclosures or barriers effective during attendance or necessary adjustments of live parts will obviate the necessity for insulating mats, and, where such mats are impracticable from the nature of the location or processes carried on, guards shall always be used.

Where connectors are used in motor leads, these should be provided with insulating covering equal to that on the conductors.

(c) *Steps and Handrails.*—Where necessary, steps and handrails should be installed on or about large machines to afford safe access to live parts which must be examined or adjusted during operation.

344. Grounding Machine Frames

Where two or more machines, either of which operates at more than 150 volts to ground, are mechanically coupled together, and the operator can touch the frames of more than one at a time, the frames of all such machines shall be permanently grounded as required by rule 304 (*c*), unless they are bonded together electrically and surrounded by insulating mats or platforms on which persons must stand in order to touch the machine frames. If operating at more than 300 volts to ground, their frames shall always be grounded as required by rule 304 (*c*), and frames shall also be grounded wherever, from the nature of the location or of processes carried on, the use or maintenance of insulating mats or platforms is impracticable.

345. Protecting Moving Parts

Suitable guards or inclosures shall be arranged at each motor or motor-driven machine when necessary to prevent persons or objects from inadvertently coming in harmful contact with moving parts, including chains, belts, gears, and pulleys.

SEC. 35. ELECTRIC FURNACES, STORAGE BATTERIES, TRANSFORMERS, AND LIGHTNING ARRESTERS

350. Protection from Burns

(*a*) *Inclosure of Glowing Parts.*—Electric furnaces and apparatus used for arc welding, where intensely glowing incandescent or arcing parts are exposed, shall be inclosed so that those parts will not be accessible or visible to unauthorized persons.

(*b*) *Screens, Hoods, Goggles.*—Suitable protecting screens, hoods, goggles, gloves, and other devices shall be provided for the authorized operators who must work or come near such exposed parts.

351. Grounding of Furnace Frames

The outside noncurrent-carrying metallic frames of furnaces shall be permanently grounded if they contain current-carrying parts connected to circuits of more than 150 volts to ground, or if the circuit within is not grounded and is exposed through transformer windings to a circuit of more than 150 volts to ground.

352. Guarding Live Parts

Except at points where necessarily left exposed (as at spot welder contacts), all current-carrying parts of furnaces, welders, and control equipment shall be suitably guarded with inclosures or barrier guards.

353. Storage Batteries, Transformers, and Lightning Arresters

(*a*) *Storage Batteries.*—The installation of nonportable storage batteries of more than 50 kilowatt-hour capacity, at the 8-hour rate of discharge, shall be in accordance with the requirements given in section 13 of the rules for stations. Where storage batteries (not included under sec. 13) are placed in rooms used also for other purposes, adequate guards or inclosures shall be provided, when it is necessary to prevent the approach of unauthorized persons, and special means of ventilation when necessary to prevent the accumulation of inflammable gas. For all batteries whose operating voltage exceeds 150, construction shall comply with rules 133 and 306 (*b*).

(*b*) *Transformers.*—The installation of transformers having either winding of more than 300 volts to ground shall comply with the rules of section 14, of the rules for stations, and if the operating voltage of any winding exceeds 750, the transformers shall be made inaccessible to unauthorized persons.

(*c*) *Lightning Arresters.*—The installation of lightning arresters shall comply with the rules of section 18 of the rules for stations, and if the operating voltage of the circuit exceeds 750 volts, the arresters shall be made inaccessible to unauthorized persons.

Lightning arresters when installed for the protection of utilization equipment may be installed on supply lines or service leads either within or without the buildings or inclosures containing the equipment to be protected. They shall be installed in accordance with the rules of Part 1, 2, or 3 depending upon their location, whether in stations, on outdoor lines, or with utilization equipment.

SEC. 36. LIGHTING FIXTURES AND SIGNS

360. Grounding

The exposed noncurrent-carrying metal parts of all lighting fixtures and other similar fixed electrical devices shall be permanently grounded when used under the following circumstances (for exception, see rule 304 *d*):

(1) When in locations where explosives, inflammable gas, or inflammable flyings exist in dangerous quantities.

(2) When within touching distance or about 8 feet from metal, concrete, or permanently damp floors or stairways, including fire escapes, galleries, or bridges, as in machine shops, stables, laundries, etc.

(3) When readily accessible from the ground or floor and also within 5 feet from conducting surfaces, such as metal piping, metal radiators, stoves, furnaces, plumbing fixtures, damp walls, or similar conducting surfaces, as in kitchens, machine shops, print shops, etc.

On grounded systems it is recommended that the center contacts of sockets and receptacles be connected to the ungrounded side of the system, and the inner screw shell of the devices to the grounded side or neutral, in order to reduce the liability of breakdown of the dielectric between the inner screw shell and the grounded outer brass shell, and also to reduce the liability of injury to persons in replacing lamps. This is especially important in wiring electric signs.

In lieu of grounding the external metal parts of lamp sockets, where suitable means for grounding are not readily available (as sometimes in the case with knob and tube wiring not near plumbing fixtures), sockets and lamp guards or similar devices of suitable insulating material may be used.

361. Insulation

Electric fixtures shall be provided with an adequate and mechanically protected dielectric (complying with the standardization rules of the American Institute of Electrical Engineers) interposed between ungrounded current-carrying parts and those external surfaces which persons can touch.

Those current-carrying parts of grills, heaters, and other heating devices, which operate at high temperatures and are necessarily exposed, are exempted.

362. Exposed Live Parts

Electric fixtures, including lamp sockets, and lamp bases, plugs, receptacles, etc., shall be so designed and installed that no current-carrying parts will normally be exposed externally.

363. Signs

(*a*) *Accessibility.*—Electric signs at an elevation greater than 30 feet above roadways or footways, or at an elevation above a roof greater than the distance from the edge of the roof, shall, if they require attendance while in position, be provided with substantial, safely accessible runways, ladders, or platforms from which all replacements and other necessary adjustments can be made. Provision for supporting workmen by safety belts should be made in the construction and installation of signs so located.

(*b*) *Inclosure of Live Parts.*—Electric signs outside buildings shall have no ungrounded current-carrying parts normally exposed to contact of workmen on or in the building.

(*c*) *Grounding of Noncurrent-Carrying Parts.*—The exposed noncurrent-carrying metal parts of a sign should be grounded if within reach of any grounded surfaces, including metal work of the building structure.

(*d*) *Control.*—Electric signs, located as in (*a*), shall be provided with switches arranged to entirely disconnect all feed wires of the sign, and either located within sight of the sign or arranged so that they can be locked in the open position.

364. Connectors for Signs

Electric signs with changeable connections shall be so arranged that such connections can be changed manually only by approved connectors in which all poles of the circuit are interrupted. All current-carrying parts of pin-and-socket connectors shall be provided with approved guards, so as not to be exposed to contact.

365. Isolating or Guarding Lamps in Series Circuits

(*a*) *Elevation.*—Arc and incandescent lamps and other devices in series circuits, except in grounded circuits, of which no part exceeds 150 volts to ground, shall be effectively isolated or suitably guarded.

Isolation will ordinarily be deemed sufficient when a vertical clearance of 8 feet is provided from floors or other ordinarily accessible places within buildings, of 10 feet from footways outside buildings, and of 15 feet from roadways. Horizontal clearance from windows, porches, and other spaces accessible to the general public should be not less than 3 feet.

(*b*) *Suspension of Lamps.*—Lamps shall be secured from falling on persons or traffic passing below, and the hanger, rope, chain, or other means adopted for holding the lamps shall be regularly and systematically inspected. Metal chains or wire cables used for lowering lamps in series circuits shall be interrupted by a suitable strain insulator, the minimum height of which from the floor or ground shall be 8 feet, whether the lamp is in position or lowered.

All metal cable or chain supports for lamps shall be effectively insulated from the lamp or shall be permanently grounded.

366. Safe Access to Arc Lamps

A suitable device shall be provided by which each arc lamp or other device on series circuits may be safely and entirely disconnected from the circuit before it is handled, unless the lamps are accessible only to properly qualified persons, worked on only from suitable insulating stools, platforms, or tower wagons, and treated always as under the full voltage of the circuit concerned.

SEC. 37. PORTABLE DEVICES, CABLES, AND CONNECTORS

[Not including those for signal systems]

370. Insulation

Portable devices shall be provided with an adequate dielectric (complying with the standardization rules of the American Institute of Electrical Engineers) interposed between ungrounded current-carrying parts and those external surfaces which persons can touch.

Toasters, grills, or other heating devices in which the current-carrying parts at high temperature are necessarily exposed are exempted. (Compare rules 352 and 361.)

In locations where the dielectric is exposed to mechanical injury it shall be suitably protected.

371. Grounding of Frames

(a) *When Adjacent to Grounded Surfaces.*—The permanent grounding of frames of portable devices (especially in connection with voltages of more than 150 to ground, and for any voltage when the devices are used within 8 feet of the floor in locations such as bathrooms, laundries, etc., where persons may easily touch grounded surfaces at the same time as the device) is recommended as a safety measure.

Such grounding may be obtained by the use of a three-wire portable cord with the portable device, one wire being used for the ground conductor and the connectors being properly designed so that wrong connections can not be made by the user of the device.

(*b*) *Sockets and Fixtures of Insulating Material.*—In lieu of grounding the external metal parts of portable lamp sockets where suitable means (as above indicated) are not readily available, sockets and lamp guards or similar devices of suitable insulating material may be used, and should be used in the hazardous locations listed previously.

372. Cable Connectors

(*a*) *Break All Conductors.*—Where used with portable conductors, it is recommended that connectors be used which necessarily disconnect both or all poles from the live source of energy where the circuit is opened.

(*b*) *Design of Connectors.*—Connectors shall be so constructed (with guards when necessary) that the person using them can not inadvertently come in contact with live parts, or be burned by arcing when interrupting the largest current for which they are rated or marked.

Separable connectors should be so designed that the plugs will not fit receptacles rated for larger currents than the plugs.

(*c*) *Live Parts of Connectors.*—The end of a separable connector which is left alive, or the two ends of a separable connector where both are connected to live circuits (as in battery charging), shall have live parts suitably guarded.

(*d*) *Strain Relief.*—Where connectors are attached to portable cables, suitable means shall be provided for relieving the terminal connections of cable from strains.

373. Identified Conductors, Cords, and Connectors

(*a*) *Portable Devices.*—Where portable devices have cases designed to be grounded and the connecting cable is provided with a separate ground conductor for this purpose (see rule

371), such ground conductor and the corresponding parts of connectors shall have suitable identification, so that the ground conductor in fixed wiring and portable cable will always be connected to the proper terminals of the connectors.

(*b*) *Separable Connectors.*—Separable connectors shall be so constructed that wrong connection between the two parts is impossible.

374. Use of Portables and Pendants

(*a*) *Voltage Limit of Portables.*—Portable and pendent conductors shall not be installed or used on circuits operating at more than 300 volts to ground, unless they are accessible only to authorized persons. In such cases they shall be of a type suited to the voltage and conditions.

In car houses and similar locations where service at low voltage is not available and where necessary to use low-voltage pendent or portable lamps or other devices in series with lamps on trolley circuits, the devices should be used only with great caution and be placed preferably on the grounded side of the circuit concerned.

(*b*) *Use of Fixed Receptacles for Portables.*—Where portable conductors are required, fixed sockets or receptacles shall be provided at safely accessible points with the more exposed conducting part attached, where practicable, to the grounded side of the circuit, and so located that liability of such conductors being brought into dangerous proximity with other live parts will be reduced as far as practicable.

(*c*) *Hazardous Locations.*—Where exposed to dampness or corrosive influences, portable conductors shall be of a type specially suited, and where exposed to inflammable gas or flyings, they shall be so protected or isolated by elevation that they can not be readily damaged. In the latter case connectors shall be so arranged as not to be exposed to accidental opening by persons handling the portable conductors or devices. Portable lamps in locations where explosives or inflammable gases are normally present shall be incased in vapor-proof globes with suitable mechanical guards.

(*d*) *Strain Relief*.—Portable and pendent conductors shall be so installed that no strain is placed on the terminal connections and shall have no joints except at suitable fittings.

(*e*) *Worn and Defective Portables*.—The use of worn or defective portable and pendent conductors should be avoided because of the danger to users by wire strands, piercing the insulating covering, or becoming exposed through abrasion of the covering.

SEC. 38. ELECTRICALLY OPERATED CARS, CRANES, AND ELEVATORS

380. Guarding Live and Moving Parts

(*a*) *Guarding and Isolation*.—All current-carrying parts connected to circuits of more than 150 volts to ground shall be so isolated or guarded that no person can inadvertently come in contact with them.

(*b*) *Conductors*.—All conductors of more than 150 volts to ground in locations accessible to the public shall be run in conduit, armored cable, or metal molding, the exposed metallic parts of which shall be permanently grounded.

(*c*) *Elevator Hoistways*.—Electrical conductors installed in or under an elevator or counterweight hoistway shall, except for flexible cables connecting the car with the fixed wiring, be incased in metal conduits or amored cables and shall be securely fastened to the hoistway. No electrical conduit or cable, except such as is used to furnish or control power, light, heat, or signals for the elevator or hoistway, shall have any opening, terminal, outlet, or junction within the hoistway, but shall be continuous between outlets or terminals situated entirely outside the hoistway.

14112°—21——18

It is not intended to prohibit the interruption of long runs for the purpose of supporting or pulling in conductors, and pull boxes may be installed for this purpose.

All live parts of electrical apparatus in elevator hoistways shall be protected against accidental contact by suitable inclosing casings or coverings, and all such casings or coverings which are made of metal shall be permanently grounded.

No part of any electric circuit whose nominal voltage exceeds 750 volts shall be connected to any elevator car. It is recommended that signal circuits be restricted to 150 volts to ground, and no signaling push buttons shall be used in circuits of more than 300 volts to ground. Circuits of higher voltage may be used in machine room or penthouse for the operation of motors, provided that all control and signal wiring is thoroughly insulated from the power circuit and all machine frames and metal hand ropes are permanently grounded.

(*d*) *Material for Guards.*—Guards required by rule 306 and (*a*) of this rule for the current-carrying parts of unisolated electrical equipment, such as controllers, motors, transformers, fuses, circuit-breakers, switches, and other devices, shall consist of cabinets, casings, or shields of permanently grounded metal or of substantial insulating material.

(*e*) *Collector Wires and Third Rail.*—Except on fenced rights of way or other locations to which only qualified persons are admitted, trolly or crane collector wires and third rails, whether indoors or out, shall be so isolated by elevation (see rule 116 and sec. 22) or be provided with suitable guards so arranged that persons can not inadvertently touch the current-carrying parts while in contact with the ground or with conducting material connected to the ground, and shall be provided with warning signs effective whenever the conductors are alive.

Damp wood, concrete floors, and metal parts of crane cabs are considered as grounded.

Trolley-contact conductors, indoors, shall be so supported that, in case of a single break, contact with the floor can not be made.

(*f*) *Arcing or Suddenly Moving Parts.*—All such parts of electrical equipment, including fuses and the handles and arc chutes of circuit-breakers, shall be so isolated or guarded that the liability of persons being struck or burned by sparking, flashing, or movement during operation, is avoided.

(*g*) *Removable Headlights.*—Headlights on electric railway cars should be so constructed that the frame becomes grounded before the lamp is connected to the ungrounded side of the circuit.

381. Grounding Noncurrent-Carrying Parts

(*a*) *Frames.*—All exposed noncurrent-carrying metal parts of electrical equipment of more than 150 volts to ground shall be permanently grounded. In electric cars all steam or hot-water heating devices accessible to the public shall also be grounded.

The ground connection through well-bonded track rails will be considered satisfactory for equipment on cars and cranes.

(*b*) *Portable Equipment.*—The metallic parts of portable cranes, derricks, hoists, and similar equipment on which wires, cables, chains, or other conducting objects are maintained should be provided with an effective protective ground (see sec. 9), where operated in the vicinity of supply lines of more than 150 volts to ground, whether the cranes or similar equipment are themselves electrically operated or not.

(*c*) *Guarding Parts on Car Roofs.*—Metal pipes or other parts extending above car roofs over trolley cars shall be well insulated from ground or else guarded by substantial guards or screens well insulated from ground, and not in electrical connection with such parts.

382. Control of Energy Supply to Cars and Cranes

(*a*) *Disconnecting Switch.*—Readily accessible means shall be provided whereby all conductors and equipment located in or on cars or cranes can be disconnected entirely from the source of energy at a point as near as possible to the trolley or other current collectors.

(b) *Main Switch or Circuit-Breaker.*—A circuit-breaker or switch, capable or interrupting the circuit under heavy loads, shall be located convenient to the operator, unless the current collector can be safely removed, under heavy loads, from the trolley or third rail.

(c) *Disconnector for Third-Rail Collector.*—Where a car is operated in locations other than private rights of way and equipped with both trolley and third-rail current collectors, means shall be provided by which any exposed third-rail collectors can be readily disconnected from the trolley circuit when not in use.

A double-throw switch the center of which is connected to the car circuit and the two sides of which are connected respectively to trolley base and third rail collector may constitute such a means.

383. Control of Movement of Cars, Cranes, and Elevators

(a) *Locking or Removable Handles.*—Means shall be provided whereby the operator (whether motorman or elevator attendant) can prevent the starting of the equipment by unauthorized persons while he is absent from his post.

Removable reverse levers or controller handles and locked doors to the operator's cab are among the most effective means.

(b) *Location of Controllers.*—The car-control lever of passenger elevators should be located so that the operator can readily face the principal car opening. For cars and traveling cranes, the car control should be so located that the operator can readily face the direction of travel.

(c) *Limit Switch.*—A limit switch shall be provided for the upper limit of travel of crane hoists and for both upper and lower limits of travel for elevators.

Limit switches shall be at least four (4) feet above lowest floor level in garages and other buildings where inflammable gases may be present.

(*d*) *Reverse-Phase Relays*.—Alternating-current motors operating freight or passenger elevators or cranes that are dependent upon phase relation for their direction of rotation shall be provided with automatic circuit-breakers (or reverse-phase relays) operative in the event of any phase failure or of phase reversal that would cause a reverse motor rotation.

384. Subway and Car Lighting

Subways and similar locations used for passenger transportation where artificial illumination is indispensable shall be lighted throughout their entire length by a system independent of the current for electric traction where such is used. It is recommended that passenger cars operated in such locations and lighted normally from the railway circuit shall be equipped with an auxiliary system of emergency lighting.

SEC. 39. TELEPHONE AND OTHER SIGNAL APPARATUS ON CIRCUITS EXPOSED TO SUPPLY LINES OR LIGHTNING

390. Guarding Noncurrent-Carrying Parts

(*a*) *Protective Requirements*.—Where telephone or other signal apparatus (not included under (*b*) below) which must be handled by persons, is permanently connected (not including portable telephones) to overhead signal circuits exposed to lightning or to supply lines of more than 400 volts to ground, provision against shock to persons handling apparatus shall be made by one or more of the following methods:

(1) The use of suitable protective devices, such as fuses and arresters, and for conditions of unusual exposure, drainage coils, or transformers, or both.

(2) The grounding of all exposed noncurrent-carrying metal parts and the suitable guarding of all ungrounded current-carrying parts. (See rule 391.)

(3) The arrangement of apparatus in such a way that persons using it will be obliged to stand on a suitably insulated platform, in a suitably insulated booth or on other insulating surfaces. (The above applies only where apparatus is accessible to none but authorized persons.)

(4) The arrangement of apparatus (on signal circuits exposed to supply lines of more than 750 volts to ground) so as to have no exposed current-carrying parts exceeding 2 square inches in area with which a person is liable to come in contact and the use of suitable protective devices, including fuses and arresters or other means.

(*b*) *Fire and Police Alarm Boxes.*—Such signaling devices as fire and police alarm boxes and telegraph test boxes, if connected to overhead signal circuits exposed to lightning or to supply lines of more than 400 volts to ground, should have the accessible noncurrent-carrying metal parts permanently grounded wherever the character of service gives valid objection to the use of arresters or transformers on the signal circuit.

Police-alarm boxes, where connected to overhead police-alarm circuits, should be protected by arresters operating at 500 volts to ground, placed in the connecting leads outside the box.

Fire-alarm boxes connected to overhead circuits, if not protected by arresters, should be provided with suitable insulating material between the circuit within and the exposed frame and operating hook, this insulation to be capable of withstanding the highest voltage of the supply circuits to which the fire-alarm circuit is exposed up to 7500 volts.

391. Guarding Current-Carrying Parts

(*a*) *Current-Carrying Parts.*—Telephone or other signaling devices which are permanently located outdoors or where exposed to corrosive fumes or dampness (such as may occur in subways, cellars, basements, laundries, stables, etc.) shall be so arranged that all ungrounded current-carrying parts are so guarded as to be suitably protected against the prevailing atmospheric conditions.

The inclosing cases of signal apparatus provide suitable guards if substantially built of metal or insulating materials.

(*b*) *Receiver Cords.*—Receiver cords shall be guarded by shields of permanently grounded metal (such as metal armor) or of nonabsorptive insulating material (such as flexible insulating tubing), or shall have suitable insulating coverings for the individual conductors.

(*c*) *Shields for Portable Cords.*—Where no protective device is installed (permissible only for fire-alarm or similar apparatus or for apparatus not for public use, where the character of service precludes the use of arresters and fuses) the shields of portable cords shall always be of grounded metal or of special insulating material suitable to withstand the voltage of the highest-voltage supply circuit to which the signal circuit is exposed up to 7500 volts.

392. Protection against Induced Voltages

All telephone or other signaling equipment which must be handled by persons and which is connected to a line that parallels a supply circuit in such manner that by reason of exposure to the supply circuit under normal conditions more than 150 volts are induced between the terminals of the signaling equipment and ground, shall be protected by one or more of the following means:

(1) All exposed metal parts of the equipment shall be insulated from the circuit, and the circuit shall be protected by arresters having a breakdown potential not exceeding one-half that of the insulation between the above-named noncurrent-carrying metal parts and the current-carrying parts.

Cords shall have an additional insulating tubing protection.

(2) All exposed noncurrent-carrying metal parts shall be permanently grounded, and all current-carrying metal parts shall either be permanently grounded or adequately shielded. (See rule 391.)

(3) All equipment shall be so located that persons coming into contact with the equipment shall be obliged to stand either on an insulated platform or in a booth of suitable insulating material. (See rule 390 *a*–3.)

393. Grounding of Arresters for Signaling Systems

The ground connections for outside installations of cable protectors employed solely to prevent electrical injury to the cable need not conform with the requirements of this rule. For rules governing the grounding of the metal cases of outdoor apparatus as covered by this section see section 9.

(a) *Methods.*—Arresters shall be permanently and effectively grounded in the following manner:

(1) The ground conductor shall perferably be of copper (or other material which will not corrode under the conditions of use) and shall be not less than No. 18 in size and in urban districts or where within buildings shall be covered with a suitable insulation.

If necessary to guard the ground conductor from mechanical injury (on poles or where a ground conductor on the outside of building walls is near a roadway, sidewalk, or pathway, thus necessarily exposing it to tampering by unauthorized persons), it shall be protected for a distance of 8 feet from the ground by a wooden molding or by conduit of nonmagnetic material.

(2) The ground connection shall be made to a cold-water pipe, where available, connected to the street mains and in service. An outlet pipe from a water tank fed by a street main may be used provided such outlet pipe is adequately bonded around the tank to the inlet pipe connected to the street main.

If a cold-water pipe is not available the ground connection may be made to a gas pipe, provided the ground conductor is attached to the pipe between the meter and the street mains.

If cold-water or gas pipes are not available, the ground connection may be made to an iron rod or pipe driven into permanently damp earth, or to a plate or other body of metal buried in permanently damp earth. (Compare rule 93.)

Steam or hot-water pipes should not be used for ground connections.

Driven rods or pipes, used as ground connections for protectors, shall not be also used as ground connections for electrical supply circuits or electrical apparatus, and where water or gas pipes are used for a ground connection, attachment to such pipes shall be made at a different point than for attachments to electrical supply circuits or equipment.

(b) *Connecting Ground Conductor to Pipes.*—Ground conductors shall be attached to pipes by means of suitable ground clamps; the entire surface of the pipe to be covered by the clamp shall be thoroughly cleaned.

(c) *Connecting Ground Conductor to Driven Rod or Pipe.*—The ground conductor shall be so attached to the rod or pipe as to give reliable connection both mechanically and electrically and in such a manner as to prevent corrosion when the joint is buried in the earth.

(*d*) *Connecting Ground Conductor to Buried Electrode.*—Where buried plate or other metal electrode is employed the ground conductor shall be securely fastened to it in such manner as to make a reliable electrical and mechanical contact.

PART 4, RULES TO BE OBSERVED IN THE OPERATION OF ELECTRICAL EQUIPMENT AND LINES

CONTENTS

SCOPE

The safety rules in sections 40–54 apply to the operation of and work on or about supply lines and signal lines used in connection therewith, and to the operation of and work on or about the electrical equipment of central stations, substations, private plants, and on or about electrical tests, and tunnel, subway, or similar underground work. They do not apply to new construction, which has not been made available for regular service.

While all the rules find application in the larger industrial or private plants and in moderate-sized utilities, some do not apply (or apply less fully) in the smaller. It has seemed unwise, however, to attempt to restrict the scope of these rules to rules which are applicable to all organizations or to all classes of electrical work.

The safety rules in sections 55–58 apply to commercial telephone, telegraph, and other signal equipment and lines, with terminology adapted to the special needs of the employees concerned.

RULES FOR THE EMPLOYER

SEC. 40. ORGANIZATION

400. Interpretation and Enforcement of Rules

(*a*) *Distribution.*—The employer shall furnish to each regular employee operating or working on electrical supply equipment, supply or signal lines, or hazardous electrical tests a copy of these safety rules for operation (or such of these rules as apply to his work), either separately or incorporated in more comprehensive rule books, and shall take means to secure the employee's compliance with the same.

(*b*) *Interpretation.*—If a difference of opinion arises with regard to the meaning or application of these rules or as to the means necessary to carry them out, the decision of the employer or his authorized agent shall be final, subject to an appeal (if taken) to the regulative body having jurisdiction.

(*c*) *Modification.*—Cases may arise where the strict enforcement of some particular rule will seriously impede the progress of the work in hand; in such cases the employee in charge of the work to be done and the employee in charge of that portion of the system on which the work is to be done may, with the consent of the chief operator concerned, make such temporary modification of the rule as will expedite the work without materially increasing the hazard.

(*d*) *Receipt.*—Many companies number their books of rules and require a receipt from each employee for his copy.

401. Organization Diagram

To better secure the safe and accurate performance of work, an organization diagram or written statement clearly showing the division of responsibility between officials and employees, down to and including the grade of foreman, should be supplied with the book of rules, or the rules should be posted conspicuously in offices and stations of the employer and in other places where the number of employees and the nature of the work warrants.

402. Address List and Emergency Rules

The rule book should contain or be accompanied by the following:

A list of names and addresses of those physicians and members of the organization who are to be called upon in emergencies.

A copy of rules for first aid, resuscitation, and fire extinguishment.

These should also be kept in conspicuous locations in every station and testing room, in line wagons, and in other places where the number of employees and the nature of the work warrants.

403. Instructing Employees

Employees regularly working on or about equipment or lines shall be thoroughly instructed in methods of first aid, resuscitation, and where advisable in fire extinguishment.

404. Qualifications of Employees

The employer shall use every reasonable means and precaution to assure himself that each employee is mentally and physically qualified to perform his work in accordance with these rules.

405. Chief Operator

(a) *Authority.*—A properly qualified chief operator, system operator, load dispatcher, general superintendent, or otherwise designated employee, whose duties shall be those prescribed in rule 430, shall be in charge of the operation of electrical equipment and lines and directly responsible for their safe operation.

(*b*) *Deputy.*—In large organizations the duties of the chief operator may be delegated for any particular section of the system to a deputy chief operator (or otherwise designated employee) who shall report as required to the chief.

(*c*) *Large Organizations.*—When it is impracticable to have the entire system placed in charge of one chief operator, the duties of the chief operator may be performed for a portion of the system by a local superintendent, local manager, or other employee who may also perform other duties.

(*d*) *Small Organizations.*—In small organizations the duties of the chief operator may be performed by the superintendent, electrician, engineer, or some other employee who may also perform other duties.

In these rules the various employees listed by above titles, including the deputy chief operator, will be designated (for simplicity) by the title of chief operator, where referred to in this capacity.

406. Responsibility

If more than one person is engaged in work on or about the same electrical equipment or lines at any one location, one of the persons shall be designated as the foreman locally in charge of the work; or all of the workmen shall be instructed as to the work they are to perform, and the employee instructing the workmen shall be considered in charge of the work.

SEC. 41. PROTECTIVE METHODS AND DEVICES

410. Attendance

Unless a qualified employee is kept on duty where generators or rotary converters are operating, such equipment shall be made inaccessible to unauthorized persons.

411. Requirement for Two Workmen

Except in trouble or emergency work, at least two employees should be provided where work is done on live lines of more than 750 volts in wet weather or at night.

412. Uninstructed Workmen and Visitors

Unqualified employees or visitors shall be prohibited from approaching any live parts, unless accompanied by a qualified employee.

413. Diagrams for Chief Operator

Diagrams or equivalent devices, showing plainly the arrangement and location of the electrical equipment and lines, should be maintained on file or in sight of the chief operator.

These diagrams may be of the entire system, of each specific portion of the system, or they may show typical arrangements.

414. Instructions to Employees

All employees shall be instructed as to the character of all equipment or lines on or dangerously near to which work must be done by them.

Instructions shall describe the equipment and lines to be worked on, identifying them by position, letter, color, number, or name.

415. Protective Devices

There shall be provided in conspicuous and suitable places in electrical stations, testing departments, and line construction and repair wagons a sufficient supply of suitable protective, first-aid, and fire-extinguishing devices and equipment, to enable employees to meet the requirements of these rules. Such devices and equipment shall be inspected or tested to insure that they are kept in good order. The following is a list of suitable devices and equipment, the kinds and numbers of which will depend on the requirements of each case:

(1) First-aid outfits.

(2) Insulating wearing apparel, such as insulating gloves, sleeves, and boots. Insulating shields, covers, mats, stools, and platforms. Insulating appliances, such as rods and tongs, for any necessary handling or testing of live equipment or lines.

(3) Protective goggles of suitable materials and construction.

(4) Tools of such special design and insulation as to eliminate so far as practicable the danger of forming short circuits across conducting parts at different potentials or bringing the user into circuit with such parts.

(5) "Men at Work" tags, log books, operating diagrams, or equivalent devices, and portable danger signs.

(6) Fire-extinguishing devices, either designed for safe use on live parts or plainly marked that they must not be so used.

(7) Grounding devices for making protective grounds.

Safety belts, whether furnished by employer or employee, should be inspected from time to time to assure that they are in safe working condition.

416. Warning and Danger Signs

There shall be displayed in conspicuous places at all unattended and unlocked entrances to electrical supply stations, substations, and testing rooms containing exposed current-carrying parts or moving parts, permanent warning signs forbidding entrance to unauthorized persons.

Suitable danger signs shall be placed in supply stations, substations, switching towers, and testing rooms about equipment having exposed current-carrying parts of more than 750 volts.

GENERAL RULES FOR THE EMPLOYEE

SEC. 42. GENERAL PRECAUTIONS

420. Rules and Emergency Methods

The safety rules should be carefully read and studied. Employees may be called upon at any time to show their knowledge of the rules.

Employees should familiarize themselves with approved methods of first-aid, resuscitation, and fire extinguishment.

421. Heeding Warnings, Warning Others

Employees whose duties do not require them to approach or handle electrical equipment and lines should keep away from such equipment or lines.

They should cultivate the habit of being cautious, heeding warning signs and signals, and always warning others when seen in danger near live equipment or lines.

422. Inexperienced or Unfit Employees

No employee shall do work for which he is not properly qualified on or about live equipment or lines, except under the direct supervision of an experienced and properly qualified person.

423. Supervision of Workmen

Workmen, whose employment incidentally brings them in the neighborhood of electrical supply equipment or lines with the dangers of which they are not familiar, shall proceed with their work only when authorized. They shall then be accompanied by a properly qualified and authorized person, whose instructions shall be strictly obeyed.

424. Exercising Care

Employees about live equipment and lines should consider the effect of each act and do nothing which may endanger themselves or others. Employees should be careful always to place themselves in a safe and secure position and to avoid slipping, stumbling, or moving backward against live parts. The care exercised by others should not be relied upon for protection.

425. Live and Arcing Parts

(*a*) *Treat Everything as Alive.*—Electrical equipment and lines should always be considered as alive, unless they are positively known to be dead. Before starting to work, preliminary inspection or test should always be made to determine what conditions exist. (See rules 440 and 461.)

(*b*) *Protection Against Arcs.*—If exposed to injurious arcing, the hands should be protected by insulating gloves and the eyes by suitable goggles or other means.

Employees should keep all parts of their bodies as distant as possible from brushes, commutators, switches, circuit-breakers, or other parts at which arcing is liable to occur during operation or handling.

426. Safety Appliances and Suitable Clothing

(*a*) *Safety Appliances*.—Employees at work on or near live parts should use the protective devices and the special tools provided, first examining them to make sure that these devices and tools are suitable and in good condition. Protective devices may get out of order or be unsuited to the work in hand.

(*b*) *Suitable Clothing*.—Employees should wear suitable clothing while working on or about live equipment and lines. In particular they should keep sleeves down and avoid wearing unnecessary metal or inflammable articles, such as rings, watch or key chains, or metal cap visors, celluloid collars or celluloid cap visors. Loose clothing and shoes that slip easily should not be worn near moving parts.

427. Safe Supports and Safety Belts

(*a*) *Safe Supports*.—Employees should not support themselves on any portion of a tree, pole structure, scaffold, ladder, or other elevated structure without first making sure that the supports are strong enough, reinforcing them if necessary.

Portable ladders should be in a safe position before being climbed. The slipping of a ladder at either end should be carefully guarded against, especially where the surfaces are smooth or vibrating.

(*b*) *Safety Belts*.—Employees should not work in elevated positions unless secured from falling by a suitable safety belt or by other adequate means. Before an employee trusts his weight to the belt, he should determine that the snaps or fastenings are properly engaged and that he is secure in his belt. Any employee who furnishes his own belt shall from time to time submit it to his employer for inspection.

428. Fire Extinguishers

Employees should avoid using fire extinguishing liquids which are not insulating in fighting fires near exposed live parts. If necessary to use them, all neighboring equipment should first be killed. (See sec. 45.)

429. Repeating Messages

To avoid misunderstandings and to prevent accidents, each person receiving an unwritten message concerning the handling of lines and equipment shall immediately repeat it back to the sender and secure his full name and acknowledgment. Each person sending an unwritten message shall require it to be repeated back to him by the receiver and secure the latter's full name.

SEC. 43. GENERAL OPERATION

430. Duties of Chief Operator

The chief operator, described in rule 405, shall keep informed of all conditions affecting the safe and reliable operation of the system, and shall keep a suitable record or log book showing all changes in such conditions. He shall read and sign such record when assuming duty and sign again on being relieved. He shall keep within sight operating diagrams or equivalent devices indicating whether electrical supply circuits are open or closed at stations under his immediate jurisdiction and where work is being done under his special authorization, provided that these devices shall not be required for any chief operators classed under paragraphs (*c*) and (*d*) of rule 405 if the record or log sheets show these conditions.

His further duties will vary according to the size and character of the system under his jurisdiction and might, for example, be about as follows:

(1) In the case of distribution from a single station, he shall direct the starting and stopping of generating equipment and the opening and

closing of outgoing circuits. He shall, in general, give permission for work to be done on live lines of more than 7500 volts and in all cases where circuits are killed at the station for the protection of workmen.

(2) In the case of a system consisting of one or more generating stations and a number of substations, he shall have supervisory charge within his jurisdiction of the operation of all generating and substation equipment and direct charge of interconnected transmission and feeder lines, and where protection of workmen is concerned, shall direct the starting and stopping of generating and substation equipment. He shall, in general, give permission for work on live lines of more than 7500 volts and on live interconnected lines, and in all cases where circuits are killed at the generating stations for the protection of workmen.

In these rules the person performing these duties is designated as chief operator, regardless of his ordinary title.

431. Duties of Foreman

(a) *Duties.*—Each foreman in charge of work shall adopt such precautions as are within his power to prevent accidents and to see that the safety rules are observed by the employees under his direction. He shall make all the necessary records, reporting to his chief operator when required. He shall, as far as possible, prevent unauthorized persons from approaching places where work is being done. He shall also prohibit the use of any tools or devices unsuited to the work in hand or which are so defective or in such poor condition as to make them unsafe.

(b) *Qualified Guides.*—The qualified persons accompanying uninstructed workmen or visitors near electrical equipment or lines shall take precautions to provide suitable safeguards and see that the safety rules are observed.

432. Special Authorization

(a) *Special Work.*—Special authorization from the chief operator shall be secured before work is begun on or about station equipment, transmission, or interconnected feeder lines or live lines of more than 7500 volts, and in all cases where lines are to be killed by regular procedure (see sec. 45) at stations, and a report shall be made to him when such work ceases.

Exceptions.—In emergency, to protect life or property, or when communication with the chief operator is difficult, due to storms or other causes, any qualified employee may make repairs on or about the equipment or lines covered by this rule without special authorization if the trouble is such as he can promptly clear with help available in compliance with the remaining rules. The chief operator shall thereafter be notified as soon as possible of the action taken. (See rule 436 *b*.)

(*b*) *Operations at Stations.*—In the absence of specific operating schedules for opening and closing supply circuits at stations, or starting and stopping equipment, employees shall secure special authorization from the chief operator before performing these operations. In all cases such special authorization shall be secured where circuit or equipment control devices are tagged at stations to protect workmen. (See rule 435.)

Exceptions.—In emergency, to protect life or property, any qualified employee may open circuits and stop moving equipment without special authorization if, in his judgment, his action will promote safety, but the chief operator shall be notified as soon as possible of such action, with reasons therefor. To maintain service, any qualified employee may also reclose circuits which have been opened by fuses or automatic circuit-breakers except where this is prohibited by rule.

(*c*) *Cutting Out Sections of Circuits.*—Special authorization shall be secured from the chief operator before sections of overhead or underground circuits are cut off by employees at points other than at stations by means of sectionalizing switches.

Exceptions.—Portions of distribution circuits of less than 7500 volts may be cut off by authorized employees, without special authorization from the chief operator, by means of sectionalizing switches, if the chief operator is thereafter notified as soon as possible of the action taken. This may also be done even for circuits of more than 7500 volts when communication with the chief operator is difficult.

433. Restoring Service After Work

No instructions for making alive equipment or lines which have been killed by permission of the chief operator to protect workmen shall be issued by him until all workmen concerned have been reported clear. When there is more than one workman at a location, a person authorized for the purpose shall report clear for such workmen, but only after all have reported clear to him. If there is more than one gang, each shall be so reported clear to the chief operator.

434. Maintaining Service

(*a*) *Closing Circuits Carrying Tags.*—When live circuits on which "Men at Work" tags have been placed are opened automatically, they should be kept disconnected until the chief operator has given proper authorization for reconnection.

(*b*) *Closing Circuits Operated Automatically.*—When overhead circuits other than trolley and third-rail circuits open automatically, the employer's local operating rules shall determine in what manner and how many times they may be closed with safety for persons on or near those circuits. The chief operator shall be advised of the conditions.

(*c*) *Grounded Circuits.*—When circuits feeding supply lines become accidentally grounded, they shall be tested to determine where the ground exists. If the ground can not be definitely located and removed by the station operator, an immediate report of the finding shall be given to the chief operator, who shall order a patrol of the lines affected to definitely locate and remove the ground as soon as practicable.

On circuits exceeding 7500 volts, it will usually be found advisable to disconnect the circuit or effectively ground the accidentally grounded conductor until the lines have been cleared of the accidental ground.

435. Tagging Electrical Supply Circuits

Before work is done under special authorization of the chief operator on or about any equipment or lines used as transmission or interconnected feeder lines, or lines operating at more than 7500 volts, or lines killed at stations or substations to protect workmen, the chief operator shall have "Men at Work" tags attached at all points where such equipment or lines can be manually controlled by regular operators to plainly identify the circuits worked on.

Before work is done on or about any equipment or lines which are killed by authorized employees at points other than at stations, the employees shall have "Men at Work" tags placed at all points where the circuit has been disconnected to identify the portion worked on.

436. Protecting Traffic

(*a*) *Barrier Guards.*—Before engaging in such work as may endanger traffic, employees shall first erect suitable barrier guards. They shall also display danger signs or red lamps from two sides of the barrier at right angles to the direction of the traffic. Where the nature of work and traffic requires it, a man shall be stationed to warn passers-by while work is going on.

(*b*) *Crossed or Fallen Wires.*—When any crossed or fallen wires which may create a hazard are found, the employee shall remain on guard or adopt other adequate means to prevent accidents and have the chief operator notified. If the employee can observe the rules for handling live parts by the use of insulating appliances, he may correct the condition at once. Otherwise he shall first secure the authorization from the chief operator for so doing. (See rule 432 *a*.)

437. Protecting Workmen by Disconnectors

When equipment or lines are to be disconnected from any source of electrical energy, for the protection of workmen, the operator shall first open the switches or circuit-breakers designed for operation under load, and then the air-break disconnectors, when provided.

SEC. 44. HANDLING LIVE EQUIPMENT AND LINES

In all these operating rules "voltage" means in general the highest effective voltage between the conductors of the circuit concerned, except that in grounded multi-wire circuits, not exceeding 750 volts between outer conductors, it means the highest effective voltage between any wire of the circuit and the ground.

In ungrounded low-voltage circuits, "voltage to ground" means in these rules the voltage of the circuit.

When one circuit is directly connected to another circuit of higher voltage (as in the case of an autotransformer), both are considered as of the higher voltage, unless the circuit of the lower voltage is permanently grounded. Direct connection implies electrical connection as opposed to connection merely through electromagnetic or electrostatic induction.

Signal equipment and lines of less than 400 volts are not considered alive, except where made alive by leakage from supply equipment or lines. They are, however, a source of danger when near live supply lines, due to their liability of being grounded.

440. General Requirements

(*a*) *Touching Live Parts.*—No employee should touch with bare hands at the same time two parts at different potential; nor should he touch with bare hands even a single exposed ungrounded live part at a dangerous potential to ground unless he is insulated from other conducting surfaces, including the ground itself, and stands on insulating surfaces.

(*b*) *Wire Insulation.*—Employees should not place dependence for their safety on the insulating covering of wires.

All precautions in this section for handling live parts shall be observed in handling insulated wires.

Insulation on a wire may look perfect, but it frequently can not be relied on to prevent shock.

(c) *Exposure to Higher Voltages.*—Every employee working on or about equipment or lines exposed in overhead construction to voltages higher than those guarded against by the safety appliances provided should as far as practicable assure himself that the equipment or lines worked on are free from dangerous leakage or induction or have been effectively grounded.

(d) *Cutting Into Insulating Coverings of Live Conductors.*—When the insulating covering on live wires or cables must be cut into, the employee should use a suitable tool. While doing such work, it is recommended that suitable goggles be worn to protect the eyes and insulating gloves to protect the hands.

When metal sheathing must be removed from cables, it should be done with special tools which will not injure the insulation. The sheathing should be so cut as to leave enough exposed insulation after the conductor has been bared to avoid arcing over between the conductor and the sheath. If the cable consists of more than one conductor, similar exposed insulating surface should be left for each conductor, using insulating separators between conductors, if necessary.

Insulating devices, such as wood separators, etc., should be examined to eliminate conducting dust or chips, sharp edges, or nails, which may defeat the purpose for which the devices are intended.

441. Voltages Between 750 and 7500

No employee should go, or take any conducting object, within six inches of any exposed live part whose voltage exceeds 750, in stations, testing rooms, in underground construction, or in overhead construction, where it is practicable to avoid this, except as follows:

(a) *Dry locations.*—In dry locations this distance may be less than six inches, if insulating devices, such as shields, covers, or gloves are placed between the person and the part or object.

The distance may also be reduced if insulating barriers (such as mats, stools, or platforms) are placed between the person and the ground, and suitable insulating shields between the person and all other conducting surfaces, except the live part, which he could accidentally touch at the same time.

(b) *Damp or Dark Locations.*—In all damp or dark locations, and wherever grounded surfaces are exposed, the distance may be less than six inches only if insulating devices are used between the person and the live parts and also between him and all other conducting surfaces with which he might otherwise come in contact at the same time.

Where safe distance from live parts can not be secured by use of the special insulating tools and appliances furnished, properly tested insulating gloves and sleeves may serve as the sole portable insulating devices between the person and live parts.

Care should be exercised in using insulating gloves to avoid puncturing them on sharp edges, especially in making wire splices. It is sometimes advisable to wear protecting gloves over insulating gloves.

442. Voltages of More than 7500

No employee should go, or take any conducting object, within the distances named below from any exposed live part at or above the voltage specified, except as permitted by this rule.

Operating voltage:	Distance in feet
7 500	1
15 000	2
50 000	3
70 000	5

Distances for intermediate voltages to be determined by interpolation.

(*a*) *Dry Locations*.—In dry locations these distances may be reduced if suitable insulating guards or barriers are placed between the person and such part or object.

(*b*) *Guards*.—If the part is being directly worked on, the tools or other mechanical appliances used shall provide the full distance of insulating material, unless protective guards are also used between the person and the live part. These protective guards may be permanent insulating covers or shields, or may be disks of insulating material, suitable for the voltages to be handled and for the attendant conditions, attached to the handles of rods or tools.

443. Requirement for Two Workmen

Except in trouble and emergency work, no employee shall work alone dangerously near live lines of more than 750 volts in wet weather or at night.

444. When to Kill Parts

No employee shall approach or willingly permit others to approach any exposed ungrounded part normally alive, except as provided in rules 440, 441, and 442 of this section, unless he has first assured himself of his own safety and the safety of those working under his direction by having the supply equipment and lines killed. (See sec. 45.)

445. Operating Switches and Working from Below

(*a*) *Opening and Closing Switches*.—Manual switches and disconnectors should always be closed by a single unhesitating motion, and, if possible, with one hand. Care should be exercised in opening switches to avoid causing serious arcing.

(*b*) *Work from Below*.—Employees should avoid working on equipment or lines from any position by reason of which a shock or slip will tend to bring the body toward exposed live parts. Work should therefore generally be done from below, rather than from above.

446. Attaching Connecting Wires and Grounds

(a) *Handling Connecting Lines.*—In connecting dead equipment or lines to a live circuit by means of a connecting wire or device, employees should first attach the wire to the dead part before attaching it to the circuit. When disconnecting, the live end should be removed first.

Loose conductors shall be kept away from exposed live parts.

Metal measuring tapes, and tapes, ropes, or hand-lines having metal threads woven into the fabric should not be used near exposed live parts

Ladders reinforced by metal in a longitudinal direction should not be used near exposed live parts.

(b) *Applying Grounds.*—In applying a grounding device to normally live parts, the device shall be grounded before being brought near the parts and shall be removed from the live parts before being removed from the ground connection.

447. Handling Series Circuits

Secondaries of current transformers to meters or other devices should not be opened when alive until a jumper has been connected across the point of opening or said secondary has been short-circuited elsewhere.

Before working on arc lights or similar devices connected to series circuits, they shall be short-circuited or (when necessary to avoid hazard) disconnected entirely from such circuits by absolute cut-outs.

448. Stringing Wires

In stringing wires near live conductors, they should be treated as alive unless they are effectively grounded.

SEC. 45. KILLING SUPPLY EQUIPMENT AND LINES

Where workmen must depend on others for operating switches to kill circuits on which they are to work, or must secure special authorization from the chief operator before themselves operating such switches, the following precautionary measures shall be taken in the order given, before work is begun on or about the equipment or lines concerned, as a means for preventing misunderstanding and accident.

In small organizations the chief operator may himself operate the switches and disconnectors instead of instructing others to do so, thus much simplifying and abbreviating the procedure. In certain cases the chief operator may direct the workman who wishes the section killed for his own protection to operate some or all switches necessary himself, thus also abbreviating the procedure.

In cases where there is no station with regular attendants at either end of a section of line to be killed for the protection of workers, the rules below need not apply for disconnection of that end of the section concerned, provided that the employee under whose direction that end of the section is disconnected is in sole charge of the section and of the means of disconnection employed or that the point of disconnection at that end of the section is suitably tagged before work proceeds.

450. Workman's Request

The workman in charge of the work shall apply to the chief operator to have the particular section of equipment or lines killed, identifying it by position, letter, color, number, or other means.

451. Opening Disconnectors and Tagging

The chief operator at his discretion shall direct the proper persons to open all switches and air-break disconnectors through which electrical energy may be supplied to the particular section of equipment and lines to be killed and shall require such person to tag such switches and disconnectors, and each tag shall be of a distinctive character indicating that men are at work. All oil switches and remotely controlled switches should also be blocked where necessary for avoiding mistakes.

The person shall, when placing the tag, record the time of disconnection, his own name, the name of the workman who requested the disconnection, and the name of the chief operator.

Where the section of equipment or lines can be made alive from two or more sources, all such sources shall be disconnected. This will apply to work on lines with more than one station, also sometimes to work on transformers in banks, rotary converters, motor generators, switches, and on other similar equipment.

452. Station Protective Grounds

When all the switches and disconnectors designated have been opened, blocked, and tagged in accordance with rule 451, the chief operator shall require each person operating them to make protective grounds (see section 46) upon the lines being killed and to report to him when such grounds are in place.

453. Permission to Work

Upon receipt of information from all persons operating switches and disconnectors that protective grounds are in place, the chief operator shall advise the workman who requested the killing of the section that the specified section of equipment or line has been killed and that he may proceed to work.

454. Workmen's Protective Grounds for Overhead Lines

The workman in charge should immediately proceed to make his own protective grounds on the disconnected lines, except under conditions where the making of such grounds will itself be more hazardous than working on the lines without grounding. Such grounds shall be made between the particular point at which work is to be done and every source of energy.

455. Proceeding with Work

After the equipment or lines have been killed (and grounded, if required by rule 454), the workman in charge and those under his direction may proceed with work without taking the precautions required on or about live parts by these rules.

456. Procedure for Other Gangs

Each additional workman in charge desiring the same equipment or lines to be killed for the protection of himself or the men under his direction shall follow the same procedure as the first workman and secure similar protection.

457. Reporting Clear—Transferring Responsibility

The workman in charge, upon completion of his work, and after assuring himself that all men under his direction are in safe positions, shall remove his protective grounds and shall report to the chief operator that all tags protecting him may be removed, and shall give his location and report as follows: "Mr. ——— and men clear and all grounds removed."

The workman in charge who received the permission to work may transfer this permission and the responsibility for men under him, as follows:

He shall personally inform the chief operator of the proposed transfer, and if this is permitted, the name of the successor shall be entered at that time on the tags concerned or in the records of the persons placing the tags and of the chief operator. Thereafter the successor shall report clear and shall be responsible for the safety of the original workmen, so far as this is affected by the removal of tags.

458. Removal of Tags

The chief operator shall then direct the removal of tags for that workman and the removal shall be reported back to him immediately by the persons removing them.

Upon the removal of any tag, there shall be added to the record the name of the chief operator and workman who requested the tag, the time of removal, and the signature of the person removing the tag.

459. Restoring Service

Only after all protecting tags have been removed by the above procedure from all points of disconnection shall the chief operator, at his discretion, direct the removal of protective grounds and blocks and the closing of any or all switches and disconnectors.

SEC. 46. MAKING PROTECTIVE GROUNDS

When making temporary protective grounds on a normally live circuit, the following precautionary measures shall be observed in the order given, and the ground shall be made to all wires of the circuit which are to be considered as grounded.

460. Ground Connections

The employee making a protective ground on equipment or lines shall first connect one end of grounding device to an effective ground connection supplied for the purpose.

461. Test of Circuit

The normally live parts which are to be grounded should next be tested for any indication of voltage, the employee carefully keeping all portions of his body at the distance required from such parts when alive by the use of suitable insulating rods or handles of proper length, or other suitable devices.

462. Completing Grounds

If the test shows no voltage, or the local operating rules so direct, the free end of the grounding device shall next be brought into contact with the normally live part and securely clamped or otherwise secured thereto before the employee comes within the distances from the normally live parts specified in rules 441 and 442, or proceeds to work upon the parts as upon a grounded part.

In stations, remote control switches can sometimes be employed to connect the equipment or lines being grounded to the actual ground connection. On lines it is generally necessary to resort to portable grounding devices or chains handled directly by means of insulating handles, rods, or ropes.

463. Removing Grounds

In removing a protective ground the employee shall not remove the grounding device from the ground connection until the device has been disconnected from all normally live current-carrying parts.

SPECIAL RULES FOR THE EMPLOYEE

SEC. 47. SUPPLY STATION AND SWITCHBOARD OPERATION

Engineers, machine attendants, switchboard operators, and helpers shall study and strictly observe the following, in addition to all the general rules in sections 42 to 46 which apply to their work.

470. Care About Machines

Do not allow oil cans, tools, dusters, or wiping cloths to catch in moving parts of machinery. In passing any switchboard or machine in operation, do not touch it unnecessarily nor allow metal tools or other metal objects to touch the apparatus or connections. Do not use iron or tin oil cans near field magnets, and use only dusters and wipers with insulating handles on or about exposed live parts.

Any employee about to work on normally moving parts of electrical equipment during periods of rest shall protect himself against their accidental starting by placing "Men at Work" signs on the starting devices, and locking or blocking these where practicable.

471. Care About Live or Moving Parts

Do not work on or near exposed live or moving parts unless authorized to do such work, and then strictly observe the rules applying.

When working near fuses and circuit-breakers or other apparatus which may arc suddenly, be careful to avoid injury from their operation.

When working on one section of a switchboard or in one compartment, mark it conspicuously and place barriers to prevent your accidental contact with live parts in that section or adjacent sections.

When working on or about live parts and standing on insulated stools or ladders, or when otherwise insulated from the ground, avoid handling metal tools or other objects to other persons who are not insulated.

472. Handling Fuses or Brushes

In handling fuses of more than 750 volts, use the special rods or tongs and stand on insulating platforms or mats, where provided. Keep the body as distant and as far below as possible.

Replace or remove link fuses from live terminals and handle brushes on live equipment only when absolutely necessary, and then with due precautions.

473. Battery Rooms

Do not smoke or cause arcing in storage-battery rooms. The use of open flames should be avoided, especially while the cells are gassing, and should be permitted only in special cases under the direct supervision of an experienced person and after the room has been thoroughly ventilated.

Do not handle live parts of batteries or their connections unless standing on insulating platforms or wearing suitable insulating boots.

474. Working in Elevated Positions

When working in an elevated position, especially above live or moving parts, assure yourself of the security of your position and support, and take precautions to avoid dropping tools or materials.

475. Handling Switchboard Equipment

All ungrounded metal parts of devices on switchboards shall be handled as if operating at the highest voltage to which any portion of the equipment on the same switchboard panel is subject, unless the parts are known, by test or otherwise, to be free from such voltage.

When cable plug connectors are used, do not allow one end to remain hanging loose while the other end is connected to a live terminal.

In handling instrument circuits, the secondary of a current transformer should never be opened when it is alive.

476. Reporting Circuit Trouble to Chief Operator

Report to your immediate superior or to the chief operator any unusual conditions of load and the indication of any accidental ground on an outgoing circuit.

477. Reporting Defects

Promptly report to your superior any dangerous conditions of equipment or surroundings, including defective tools, switches, or protective devices, or live cases or frames of apparatus or instruments.

SEC. 48. OVERHEAD LINE OPERATION

Linemen and assistants and groundmen, in construction, extension, removal, or repair work, shall study and strictly observe the following, as well as all the general rules in sections 42 to 46, which apply to their work.

480. Testing Structures Before Climbing

Before climbing poles, ladders, scaffolds, or other elevated structures, first assure yourself that the pole, ladder, scaffold, tree, cross arm, messenger wire, cable car, or boatswain's chair, or other elevated support, is strong enough to safely sustain your weight.

Poles may be tested for decay near the ground line with a bar, screw driver, or other tool, and sounded for decay at the center by rapping with a heavy tool or block of wood.

When poles or cross arms are apparently unsafe from decay or unequal strains of wires on them they should be properly braced or guyed, if necessary, before they are climbed.

481. Use of Pole Steps

When poles are stepped, make use cf such steps in climbing.

Do not support yourself by pins, brackets, or conductors.

482. Spurs

Spurs with gaffs worn short shall not be used. The gaffs on spurs shall be kept sharp, and spurs shall fit properly. Spurs shall not be worn on work for which they are not required, nor while men are traveling to or from work.

483. Care About Live Parts

Do not go among any wires until you know their voltage.

Leaning over and crowding through unprotected wires should be avoided wherever possible. Place yourself so that you will not be liable to fall on wires should an accident occur.

Do not depend on the insulating covering of wires, and treat all lines as alive unless they have been properly killed (except signal lines known to be clear).

Avoid use of hand lines or measuring tapes containing metal strands.

In handling dangerous switches or fuses, do so only by means of suitable insulating handles, rods, or tongs.

484. When Touching Live Parts

When working on live equipment or lines never allow any portion of the body to come in contact with any live or grounded part other than that worked on.

While touching supply lines or equipment, avoid as far as possible touching ground wires, guy wires, span wires, metal pipes, metal poles, metal sheaths, signal lines or equipment, transformer cases, hangers, and other metal fixtures.

Signal lines are included principally because of their liability of being grounded.

The other equipment and lines listed may become either alive or grounded.

While touching signal lines or equipment, metal sheaths metal pipes, ground wires, or metal fixtures on poles, avoid as far as possible touching supply lines or equipment, guy or span wires.

485. Protecting Traffic

When working overhead, keep tools and materials not in use in proper receptacles; tools or materials should not be thrown to or from the man on the pole, but should be raised or lowered by means of a hand line, using proper receptacles where practicable.

Do not unnecessarily stand where you can be struck by materials dropped by men working overhead.

Pole holes and obstructions along public highways and other frequented places shall be protected by watchmen or by suitable guards or danger signals so located as to be conspicuous to traffic.

When working overhead, or hoisting or lowering materials above places where frequent traffic occurs, a man should be stationed to warn passers-by.

Where traffic is light, warning signs or barriers may be used in lieu of watchmen. Where traffic is congested, it may be necessary to rope off the space.

486. Stringing Lines

Never string wire near live lines except by means of suitable insulating hand lines or other appliances. Avoid bringing them in contact with the live lines. Regard them as live wires of the same voltage because of their liability to come in contact with the live lines.

Never change the strains on a pole by adding or removing wires until assured that the pole will stand the altered strains.

In stringing wires do not allow them to sag so as to endanger vehicles or pedestrians below, unless traffic is intercepted by watchman or otherwise.

487. Reporting Defects

Report promptly to your immediate superior any dangerous conditions of your own or other utilities observed arising from defective insulators, pins, cross arms, abnormally sagging wires, etc.

SEC. 49. UNDERGROUND LINE OPERATION

All cable splicers and other workmen in underground construction or operation shall study and strictly observe the following in addition to the general rules in sections 42 to 46 which apply to their work.

490. Guarding Manholes, Handholes, and Street Openings

When removing manhole or handhole covers or making excavations, promptly protect the opening with a barrier, temporary cover, or other suitable guard, and see that danger signals or red lights are displayed in a location conspicuous to the traffic until permanent covers are in place or the excavations are filled.

491. Testing for Gas

Do not enter manholes until you have assured yourself that the manholes are free from dangerous gases, by testing with approved safety lamps, by ventilation, or by other adequate methods. (See rule 581.)

492. Watchman on Surface at Manholes

Do not enter a manhole unless a temporary cover is placed over the opening or a watchman is stationed at the surface. Where any gas is liable to be present always see that the watchman is stationed at the surface. Where any hazard is involved do not leave a manhole unwatched until all workmen are out.

493. Avoiding Flames

Do not smoke in manholes and avoid as far as practicable open flames or torches in or near manholes.

Avoid sparks in handling live parts or cable sheaths and avoid igniting the flux in soldering and wiping joints. In using hot paraffin see that it does not reach a temperature at which it will ignite. (See rule 583.)

494. Pulling Cables

When pulling in cables make sure that the gear can not slip so as to injure workmen. Avoid the danger of having the hands drawn into the tackle by the pulling line.

495. Testing and Splicing Live Cables

If lines and cables are not properly identified by markings or positions, do not work upon them.

Always ascertain, if practicable, whether cables are alive, by testing with the test devices provided, before cutting into the cable sheaths. Live cable should be spliced only by men experienced in the work, and they should use extreme caution and suitable devices in so doing.

496. Reporting Defects

Promptly report to your immediate superior any dangerous condition of your own or other utilities, whether observed in underground or overhead construction. Particularly report insanitary conditions, gas or missing cable tags in manholes, and abnormally sagging wires or broken supports in overhead construction.

SEC. 50. SERIES LAMP OPERATION

All series lamp trimmers, hangers, and inspectors shall study and strictly observe the following, in addition to the general rules in sections 42 to 46, and the special rules under the sections for overhead and underground operation, respectively, in sections 48 and 49, which apply to their work.

500. Precautions on Series Circuits

Series lamps and devices in series circuits should always be treated as alive unless disconnected by absolute cut-outs or protected by the grounding of the circuit (see section 46).

501. Handling Series Lamps

Trimmers, inspectors, or patrolmen shall wear suitable insulating gloves and stand on insulating platforms or dry, well-seasoned wood poles while touching series lamps or their cut-outs, when these are alive.

Where stools or tower wagons are used which provide sufficient insulation from ground for the voltages to be handled, the insulating gloves may be dispensed with.

502. Bridging Series Lamps

Before working on lamps or other devices in live series circuits always bridge the device with jumpers such as series lamp cut-outs usually provide, so that the circuit can not be opened at the device and possibly be completed through your body or arc at the point of opening and burn you.

503. Testing Series Lamp Circuits

Series lamp circuits should not be tested at their full operating voltage unless it is impracticable to test otherwise. Tests should be made only in accordance with a time schedule, concerning which all persons whose safety may be affected are informed.

504. Periodically Disconnected Circuits

If circuits, such as series lamp circuits, are not effectively grounded during the idle period, all rules for handling live parts shall be strictly observed.

505. Reporting Defects

Report promptly to your immediate superior any abnormally sagging wires, broken insulators, leaning poles, defective pole steps, broken globes or lamp supports, and other defects giving rise to a dangerous condition of your own or other utilities, or any indication of voltage on lines supposed to be dead.

SEC. 51. METER OPERATION

All meter setters and testers shall study and strictly observe the following in addition to all the general rules in sections 42 to 46, which apply to their work.

510. Taped Joints

Never leave joints or loose ends of wires untaped unless otherwise protected.

511. Care About Live Parts

Do not use bare fingers or hands to determine whether a circuit is alive. Never remove or replace fuses in live circuits of more than 750 volts except by means of the suitable appliances provided.

512. Opening Circuits at Switches

Special care should be exercised in opening circuits at meter connections unless the circuits have been first properly opened at switches.

513. Current Transformer Secondaries

Before working on an instrument or other device in a current transformer secondary circuit, always bridge the device with jumpers, so that the circuit can not be opened at the device. Never open such a circuit at meter connections until it has been elsewhere bridged.

514. Special Tools

Use only hand tools suited to the work in hand, and so reduce the danger of short circuits.

515. Reporting Defects

Promptly report to your immediate superior any live meter case or any condition of a meter or its connections of the interior wiring or of overhead lines, of your own or other utilities, which might endanger life and property.

SEC. 52. TESTING OPERATIONS

All electrical testers, helpers, and others working about electrical tests shall study and strictly observe the following in addition to all the general rules in sections 42 to 46. Owing to the diversified character of testing work, this study should usually extend also to the special rules in sections 47 to 54.

520. Authorization for Work

Do not work on or about equipment or lines without first receiving authorization from the person in charge.

such equipment or lines are under control of a chief operator, this au-[illegible]tion must come from him. This will include the attaching of tags [illegible]e proper points and the observation of all rules for general operation [illegible] section 43.

521. Checking of Conditions

Thoroughly familiarize yourself with all conditions surrounding equipment or lines to be tested before making any change in these conditions.

Do not make any change in equipment or lines unless you fully understand the effect of the change.

522. Foreman

One properly qualified person shall be in immediate charge of all testing work, or all of the workmen shall be instructed as to the work they are to perform and the employee instructing them shall be considered in charge of the work.

523. Warnings and Barriers

Display danger signs and erect suitable guards about all equipment or lines under test when in places where traffic is frequent, if live or moving parts would otherwise be exposed.

When temporary wiring, belts, pulleys, or other temporary live or moving parts must be guarded, suitable portable guards and warning signs shall be used.

524. Requirement for Two Workmen

No person should work alone in testing or experimental work on or about parts on which the voltage can exceed 750 volts, except in routine testing where the live parts are properly guarded.

525. Reporting Defects

Promptly report to your immediate superior any conditions of equipment or lines under test which may endanger life or property.

SEC. 53. TUNNEL AND SUBWAY OPERATION

Tunnel and subway electricians, operators, and others working on or about underground electrical equipment (not in stations, substations, or in underground conduit systems) shall study and strictly observe the following, in addition to the rules in sections 42, 43, 44, 47, and 49, so far as they apply to their work.

Dangerous Locations.—The value of insulation (insulating covering) as protection from shock is reduced by the dampness usually present in these and similar locations. The restricted spaces often bring the worker closer to equipment and wires than in other kinds of electrical work, and the imperfect illumination also makes special care necessary to avoid contacts. The human body and all surrounding surfaces become more conducting where dampness exists, and electrical shocks are therefore more severe.

530. Live Electrical Parts

Before handling any electrical equipment or wires, make sure whether they are alive or dead. It is not advisable to work on live equipment or wires when the current can be shut off without interrupting necessary operations.

Never touch or disturb any electrical equipment or wires without being authorized.

531. Standing on Ground

Do not touch any electric wire, cable, or third rail, no matter how well it is insulated, while you are standing on the ground or on any pipe, track, rail, or other conducting surface, unless insulated from the latter.

Do not touch the metal frame or case of a motor unless you are insulated from the ground or the frame is effectively grounded.

Remember that the surfaces of damp ground and water are conducting. Insulation on a wire may look perfect, but it can not be relied on to prevent shock.

532. Carrying Tools

In carrying tools or metal implements in passageways containing electric wires, especially near exposed trolleys, never permit the tools or implements to touch them.

In particular, do not carry such objects on the shoulder when there are conductors overhead. Do not carry objects on that side of passageways where third rails or side trolley wires are exposed.

533. Handling and Repairing Live Parts

When necessary to handle or repair live trolley wires, third rails, cables, motors, or other electrical equipment, wear suitable insulating gloves or stand on the waterproof insulating mats or platforms provided.

Do not rely entirely on gloves for protection. The gloves may have been punctured since they were previously tested.

Before handling or making use of any electrical cable, carefully examine it to make sure that its insulation is not injured.

Portable cables should be inspected at least once daily during the period of their use.

534. Handling Portable Devices

In handling portable motors or lamps, first make sure that the external metal frame is not alive by contact with or leakage from live parts within.

Have such portable devices inspected at least once daily during the period of their use.

535. Fuses and Switches

Never handle fuses or close switches or circuit-breakers unless you are authorized to perform that special duty, and then use the insulating handles or rods provided.

Before closing switches first make sure that you are not endangering other persons.

536. Injuring Cables and Wires

Do not fire shots, handle tools, or perform other work in such a manner as to injure cables or wires in the vicinity. If in doubt, consult your superior.

537. Temporary Wiring

Never arrange the wiring of any temporary circuit for earth return, nor use bare conductors.

This particularly applies to the temporary portions of shot-firing circuits and to the leads of portable motors and lamps.

Never employ temporary circuits without seeing that there are installed at the junction with the permanent wiring, suitable disconnecting switches or plug connectors, arranged to disconnect all conductors of the temporary circuit by a single operation.

For shot-firing circuits their disconnectors should be left open until the shot is to be fired, and should preferably be arranged for locking in the open position.

538. General Precautions

Never get on or off locomotives or cars on the side where the trolley wire or third rail is located.

Do not place combustible or explosive materials near electric wires, trolley tracks, third rails, or motors.

Do nothing that will cause sparking, or expose parts that may arc or spark during operation, if any explosive gases are present.

539. Reporting Dangerous Conditions

Promptly report to your superior any dangerous or unusual conditions observed. In particular, report the presence of gas, broken insulators, bad insulation on wires, defective third-rail construction, live frames of motors, broken ground wires on motor frames, and sparking, arcing, or shocks noticed at any point.

Report also any fallen, crossed, or abnormally sagging wires, whether electric wires or not. This includes trolley wires at switches and crossings and wires injured through falling roofs.

SEC. 54. SIGNAL LINE OPERATION

All men working on or near telephone and telegraph lines operated in connection with supply lines shall study and strictly observe the following, in addition to all the general rules in sections 42, 43, and 44, and the special rules in sections 48 and 49, which apply to their work. For rules governing the operation of commercial signal lines see sections 55–58.

540. Official in Charge of Operations

In those rules where the words "chief operator" are used the official in charge of safeguarding operation is to be understood.

541. Precautions Before Climbing Poles

Before climbing poles or other structures to work on or about signal lines, especially where occupied in common with, or running near power circuits, make a careful inspection to ascertain if possible whether there are any crosses with supply circuits.

Apply mechanical tests as far as practicable to messenger wires before trusting the wires to carry your weight.

542. Approaching Supply Lines

Avoid contact with all wires other than those you know to be signal wires, assuming such other wires always to be alive. Signal wires in trouble may be in contact with supply lines at some distant point and should be treated with proper care.

Do not approach any supply line or supply equipment within the distances given in rules 441 and 442 unless you comply with all the rules under that section, as far as they apply.

543. Touching Equipment

While handling signal lines, metal sheaths, or signal equipment avoid touching guy or span wires and supply lines or equipment. Especially avoid standing on or touching transformer cases, hangers, or connections.

While touching open signal lines avoid contact also with grounded parts such as sheaths and ground wires.

544. Stringing Wires

When stringing wires or cables over or under supply lines, avoid any possibility of their coming in contact. Do not string them above live supply lines where it is practicable to avoid it.

Where liability of contact can not be entirely avoided, the lines being handled shall be treated as alive (unless they are effectively grounded), and the rules in section 44, so far as they are applicable, shall be carefully observed.

545. Reporting Dangerous Conditions

Promptly report to the proper official abnormally sagging wires, broken or defective insulators, pins, cross arms, defective poles, or any other dangerous conditions of your own or other utilities.

RULES FOR COMMERCIAL TELEPHONE AND TELEGRAPH SYSTEMS

These rules apply also to fire and police-alarm systems, district messenger systems, and other signal systems not operated in connection with supply lines. For rules on the latter see section 54.

SEC. 55. RULES FOR THE EMPLOYER—SIGNAL SYSTEMS

550. Distribution and Enforcement of Rules

(a) *Distribution.*—The employer shall furnish to each regular employee working on or about commercial telephone or telegraph equipment or lines, safety rules governing his conduct while so engaged, and shall take suitable means to secure the employee's compliance with the same.

(b) *Form.*—The safety rules furnished to any employee may be in such form as the employer may determine is best suited to the needs of individual employees. They shall, however, include the principles set forth in the following rules, or at least such part thereof as is applicable to the work in which the employee is engaged, and shall not conflict with these rules.

(c) *Interpretation.*—If a difference of opinion arises with regard to the meaning or application of these rules, or as to the means necessary to carry them out, the decision of the employer or his authorized agent shall be final, subject to an appeal (if taken) to the regulative body having jurisdiction.

551. Address List and Emergency Rules

The rule books should contain or be accompanied by the following:

(1) A list of names and adresses of those physicians and members of the organization who are to be called upon in emergencies.

(2) A copy of rules for first aid, resuscitation, and fire extinguishment.

These should also be kept in conspicuous locations in central stations, on line wagons and in other locations where the number of employees and nature of the work warrants.

552. Instructing Employees

Employees regularly working on or about signal equipment or lines, if their duties render such training necessary, shall be thoroughly instructed in approved methods of first aid, resuscitation, and fire extinguishment, and if advisable regularly drilled.

Groups of employees, such as commercial telephone operators, shall be thoroughly drilled to make prompt and orderly exit from buildings in case of fire.

553. Qualification of Employees

The employer shall use every reasonable means and precaution to assure himself that each employee is mentally and physically qualified to perform his work in accordance with these rules, and that he is not addicted to the use of intoxicants and habit-forming drugs.

554. Protective Devices

There shall be provided in conspicuous and suitable places in stations and on line wagons a sufficient supply of suitable protective, first-aid, and fire extinguishing equipment to enable employees to meet the requirements of these rules. Such devices and equipment shall be inspected or tested to insure that they are kept in good order. The following is a list of suitable devices and equipment, the kinds and numbers of which will depend on the requirements of each case: (*a*) First-aid outfits; (*b*) insulating wearing apparel, such as insulating gloves, boots, and shields; (*c*) safety belts; (*d*) fire-extinguishing apparatus.

SEC. 56. GENERAL RULES FOR THE EMPLOYEE—SIGNAL SYSTEMS

560. Heeding Warnings, Warning Others

Employees should cultivate the habit of being cautious, heed warning signs and signals, and always warn others when seen in danger near equipment and lines.

561. Inexperienced or Unfit Employees

No employee shall do work for which he is not properly qualified on or about equipment or lines, except under the direct supervision of an experienced and properly qualified person.

562. Electrical Supply Equipment or Lines

Workmen whose duties do not require them to approach or handle electrical supply equipment and lines should keep away from such equipment or lines.

Electrical supply equipment and lines should always be considered as alive unless positively known to be dead.

563. Safe Supports and Safety Belts

(*a*) *Safe Supports.*—Employees should not support themselves on any portion of a tree, pole structure, lamp bracket, or similar fixtures on poles, scaffold, ladder, roof, skylight, or other elevated structure without first making sure that the supports are strong enough, reinforcing them if necessary.

Portable ladders should be in a safe position before being climbed. The slipping of a ladder at either end should be carefully guarded against, especially where the surfaces are smooth or vibrating.

Insecure makeshift substitutes for ladders should not be used. An employee should never trust his weight on thin wooden boxes, sinks, washbowls, window shelves, or chair backs.

A ladder should not be placed upon a box, barrel, or other movable or insecure object.

Care should be taken to see that chairs, rolling ladders, and similar equipment are in first-class condition before being used.

(b) *Safety Belts.*—Employees should not work in elevated positions unless secured from falling by a suitable safety belt or other adequate means (sometimes including suitably located pole steps). Before an employee trusts his weight to the belt, he should determine that the snaps or fastenings are properly engaged and that he is secured in his belt.

(c) *Safety Ropes.*—Ropes used for supporting boatswains' chairs, platforms, or for other purposes on which the security of the employee depends shall be frequently inspected to assure that they are maintained in good condition.

564. Duties of Foreman

(a) *Duties.*—Each foreman in charge of work (see rule 406) shall see that the safety rules are observed by the employees under his direction. He shall make all necessary records; reporting to his superior when required. He shall permit only authorized persons to approach places where work is being done.

He shall adopt such precautions as are within his power to prevent accidents, and prohibit the use of any tools or devices not suited to the work in hand or defective.

(b) *Qualified Guides.*—The qualified person accompanying uninstructed workmen or visitors near electrical equipment or lines shall take precautions to provide suitable safeguards and see that the safety rules are observed.

565. Handling Live Parts

No employee should touch, with bare hands, any exposed ungrounded live part of more than 150 volts to ground, unless he is insulated from other conducting surfaces, including the ground itself. When employees must touch, at the same time, two parts between which a considerable potential exists, insulating gloves or other protection shall be used.

566. Power Circuits in Central Offices

When making repairs on electric light or power circuits, the circuits shall, whenever possible, be made dead.

Where practicable, moving apparatus, as for example, fans, shall be stopped before working upon it.

None other than duly authorized persons shall be admitted to central office transformer vaults or battery rooms.

Care shall be used while working on or near circuits of more than 150 volts to ground, particularly in alternating-current districts.

567. Handling Fuses or Brushes

When working on the brushes of a machine in operation, employees shall use care not to break a circuit, the flashing of which may injure the eyes or burn the hands. If it is necessary to remove a brush from the holder, the machine shall be shut down.

When inspecting or changing fuses, care should be taken to prevent injury to the eyes. If it is necessary to handle the fuses, the circuit should be cut off, if possible.

568. Battery Room

Do not smoke or cause arcing in storage-battery rooms. The use of open flames should be avoided, especially while the cells are gassing, and should be permitted only in special cases under the direct supervision of an experienced person and after the room has been thoroughly ventilated.

SEC. 57. SPECIAL RULES FOR OVERHEAD LINE OPERATION SIGNAL SYSTEMS

570. Testing Structures Before Climbing

Before climbing poles, ladders, scaffolds, or other elevated structures first assure yourself that the pole, ladder, scaffold, tree, cross arm, messenger wire, cable car, or boatswain's chair, or other elevated support is strong enough to safely sustain your weight.

On pole replacement work no pole shall be climbed for the purpose of clearing it of all wires and cables without first guying or bracing the pole securely.

Where poles or cross arms are apparently unsafe from decay, or unequal strains of wire on them, they should be properly braced or guyed, if necessary, before they are climbed.

An uncoiled hand line, rope, or wire of any sort should not be fastened to the employee while climbing a pole, but where this must be done the employee should exercise due care to prevent the line from catching on obstructions.

In climbing poles careful watch should be kept for nails or other foreign attachments which might catch in the clothing and cause a fall.

571. Use of Pole Steps

When poles are stepped make use of such steps in climbing, first making sure that the steps are firmly set in solid material before trusting one's weight upon them. Pay particular attention, on icy poles, to each step.

Do not support yourself by pins, brackets, or conductor wires.

572. Spurs

Spurs with gaffs worn short shall not be used. The gaffs on spurs shall be kept sharp and spurs shall fit properly. Spurs shall not be worn on work for which they are not required, nor while men are traveling to or from work.

573. Approaching Supply Lines

Avoid contact with all wires other than those you know to be signal wires, assuming such other wires always to be alive. Signal wires in trouble may be in contact with supply lines at some distant point, and should be treated as live supply lines unless known to be free from any dangerous voltage.

Do not approach any supply line or supply equipment within the distances given in rules 441 and 442 under section 44, unless you comply with all the rules under that section.

574. Touching Equipment

While handling signal lines, metal sheaths, or signal equipment avoid touching trolley or arc lamp span wires and supply lines or equipment. Especially avoid standing on or touching transformer cases, hangers, or connections.

575. Care About Electrical Supply Lines

Do not go among any wires until you know their voltage.

Leaning over and crowding through unprotected supply wires should be avoided wherever possible. Place yourself so that you will not be liable to fall on supply wires should an accident occur.

Do not depend on the insulating covering of wires, and treat all lines as alive unless they have been killed properly (except signal lines known to be clear).

Treat also as alive all wires (unless thoroughly grounded) which are being strung near supply lines; regard them as being of the same voltage as the supply lines.

Avoid use of hand lines or measuring tapes containing metal strands.

When necessary to work in the vicinity of supply lines, transformers, and similar equipment assure yourself before starting work that the position of the body is such that should you momentarily forget yourself or fall no portion of the body will come in contact with the foreign wires or equipment. Have the supply lines approached killed where possible.

Railway span wires, pull-offs, and trolley brackets shall be treated as if alive, even though equipped with strain or other insulators.

576. Stringing Lines

Never string wires near live lines except by means of suitable insulating hand lines or other appliances.

Avoid the use of wire or twisted pair as a substitute for a hand line.

Wires should not be strung above live lines operating at more than 750 volts, unless the wires being strung are effectively grounded or otherwise suitably protected, or in handling them all the precautions are observed as provided in rules 441 and 442, for work on parts at the voltage of the lines concerned, and the spacings maintained.

Never change the strains on a pole by adding or removing wires until assured that the pole will stand the altered strains.

When wires are being pulled up on corner poles employees should stand in such a position that they can not be struck by the wire in case it slips.

Where it is necessary to remove signal wires below which are supply lines, power should be shut off of the supply lines where possible, and if this is not practicable rope cradles and suitable guards should be erected. Extraordinary care should be exercised to prevent the signal wires from sagging into the supply lines.

When running wires, cables, cable strand, span wires, or guys across streets, sidewalks, or highways the coil or reel shall not be left unattended, nor shall the center of any span be permitted to sag sufficiently to come into contact with vehicles or pedestrians unless a helper is stationed to warn passers-by until the slack can be removed.

When stringing wires for long distances, precautions shall be taken to prevent the possibility of vehicles or pedestrians coming into contact with the wires at the intersecting streets or highway crossings.

577. Protecting Traffic

When working overhead, keep tools and materials not in use in proper receptacles; tools or materials should not be thrown to or from the man on the pole, but should be raised or lowered by means of a hand-line, using a proper receptacle. Also tools and loose materials should not be left at the top of poles, ladders, or other elevated structures.

Workmen shall not stand where they are liable to be struck by materials dropped by men working overhead.

Pole holes and obstructions shall be protected by watchmen or by suitable guards and danger signals or lights in a location conspicuous to traffic.

When working overhead or hoisting or lowering materials above places where traffic occurs, a man should be stationed to warn passers-by.

Where traffic is light, warning signs may be used in lieu of watchmen. Where traffic is congested, it may be necessary to rope off the space.

578. Reporting Dangerous Conditions

Report promptly to your immediate superior any dangerous conditions of your own or other utilities observed arising from defective insulators, pins, cross arms, abnormally sagging wires, etc.

Any imminently dangerous conditions shall be guarded until they can be made safe.

SEC. 58. SPECIAL RULES FOR UNDERGROUND LINE OPERATION—SIGNAL SYSTEMS

580. Guarding Manholes, Handholes, and Street Openings

When removing manhole or handhole covers or making excavations, promptly protect the opening with a barrier, temporary cover, or other suitable guard, and see that danger signals or red lights are displayed in a location conspicuous to the traffic until permanent covers are in place or the excavations are filled.

581. Testing for Gas

Do not enter manholes until you have assured yourself that the manholes are free from dangerous gases, as indicated by approved safety lamps, by ventilation, or by other adequate methods.

When work is being carried on in manholes for any length of time where gas collects, suitable ventilation shall be provided or tests with the safety device should be repeated at regular intervals to make certain that gas is not accumulating in the manhole in dangerous quantities.

582. Watchman on Surface at Manhole

Do not enter a manhole unless a man is stationed at the surface.

Do not leave a manhole unwatched until all workmen are out.

583. Avoiding Flames

Do not smoke in manholes, and avoid as far as practicable open flames or torches in or near manholes.

If it is necessary to illuminate a manhole, electric lights only should be used. When doing this, it should be known that the leads, sockets, and connections are well insulated and in good condition in order to avoid the possibility of a spark. Special attention should be paid to the sparking of any motors used for ventilating purposes.

Avoid sparks in handling live parts or cable sheaths, and avoid igniting the flux in soldering and wiping joints. In using hot paraffin see that it does not reach a temperature at which it will ignite.

In central office cable vaults tests shall be made for the presence of gas before using exposed flames, and such flames shall not be used in vaults where gas collects.

584. Pulling Cables

When pulling in cables, make sure that the gear can not slip so as to injure workmen. Avoid the danger of having the hands drawn into the tackle by the pulling line.

585. Reporting Dangerous Conditions

Promptly report to your immediate superior any dangerous condition of your own or other utilities, whether observed in underground or overhead construction. Particularly report insanitary conditions, gas, or missing cable tags in manholes and abnormally sagging wires or broken supports in overhead construction.

INDEX TO RULES

[References are to rule numbers. The following abbreviations are used: Def. for definition; app. for appendix; sec. for section.]

A

B

C

F

G

M

S

T

U